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# THE GEOGRAPHICAL JOURNAL

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# The Geographical Journal

Vol. LXI No. 2 February 1923


## THE VOYAGE OF THE "QUEST"


Commander Frank Wild, C.B.E.



*Read at the Meeting of the Society, 13 November 1922.*


SIR ERNEST SHACKLETON'S first intention in starting a new expedition was to enter the Arctic, and not the Antarctic where all his previous work had been done. In spite of the long siege which has been carried out in the Arctic regions there is still a large blank space on the map comprising what is known as the Beaufort Sea. A point placed approximately in the middle of the area has been called by Stefansson the "centre of the zone of inaccessibility." It was the exploration of this area that he made his aim.

Before proceeding with any part of the organization he wrote to Mr. Stefansson to ask if the new expedition would interfere with any plans of his. He received in reply a letter saying that not only did it not interfere in any way, but that he (Stefansson) would be glad to afford any help that lay in his power, and put at his disposal any information which might prove valuable.

The proposed expedition would have had the added interest in that an Antarctic explorer of repute was to tackle a big problem in the Arctic. The plans met with instant recognition from scientific people, and amongst others the Council of the Royal Geographical Society sent an appreciation of the importance of the work, and an approval of Sir Ernest Shackleton as being thoroughly competent to undertake it. He was fortunate in securing the co-operation of Dr. H. R. Mill, who very kindly placed at Sir Ernest's disposal his authoritative knowledge of Polar exploration in all its branches.

The scheme was a most fascinating one, but was very ambitious, and the estimated cost of it was very great. In this country Shackleton received the support of Mr. John Quiller Rowett, whose interest in all scientific affairs is very keen, and who has supported research in agriculture, medicine, and chemistry; and of Sir Frederick Becker. He received also the promise of support from the Canadian side of the water, which placed him in a position to start his work. He threw himself with energy into the plans. I received in Central Africa a cablegram asking me to come again as his second-in-command, and cabled back

an immediate assent. Dr. Macklin was sent to Canada to buy a hundred good sledge dogs. Commander Worsley, Dr. McIlroy, and Captain Hussey were also sent for, and immediately gave up their work to join in the new enterprise. A ship was bought which cost as an initial outlay £11,000, and preparation was in full swing when the news was suddenly received that the Canadian support would not be forthcoming.

Shackleton took the blow with apparent equanimity. His plans had been brought to maturity as the result of many years' hard work and careful thought, yet he started resolutely even at this eleventh hour to remodel his plans. Cherry-Garrard in his new book says, "If I am in a devil of a hole and want to get out of it, give me Shackleton every time." Nevertheless the situation was a difficult one, for he had committed himself to heavy expenditure, and what weighed not least with him at this time was his consideration for those who had come to join the enterprise.

It was at this point that Mr. Rowett came forward and took upon his shoulders practically the whole financial responsibility of the expedition. The importance of his action cannot be too much emphasized, for without it the expedition would have been impossible. His generous attitude is the more remarkable in that he knew that there was no prospect of financial return, and what he did was in the interest of scientific research and from friendship to Shackleton.

The delay involved made the catching of the Arctic open season impossible, so a scheme for work in the South was evolved, which again met with the approval of the chief scientific bodies.

The proposed route in the new scheme led to the following places: St. Paul Rocks on the Equator, South Trinidad Island, Tristan da Cunha, Inaccessible Island, Nightingale and Middle Islands, Diego Alvarez or Gough Island, and thence to Cape Town. Cape Town was to be the base for operations in the ice, and a depôt of stores for that part of the journey was formed there. Continuing the route led to Marion, Crozet, and Heard Islands, and then into the ice where the track to be followed was of course problematical, but would lead westwards to emerge again at South Georgia. From South Georgia it led to Bouvet Island and back to Cape Town to re-fit. From Cape Town the second time it included New Zealand, Raratonga, Tuanaki (the "lost island"), Dougherty Island, the Birdwood Bank, and home viâ the Atlantic.

The scientific work comprised meteorological observations including air and sea temperatures, kite and balloon work, magnetic observations, hydrographical and oceanographical work, with an extensive series of soundings and the mapping and careful charting of little-known islands. Search was to be made for lands marked doubtful. A collection of natural history specimens would be made and a geological survey and examination carried out in all places visited. Ice observations would be carried on in the South and an attempt made to reach and map out

new land. Photography was made a special feature, and a large and expensive outfit of cameras, cinematograph machines, and general photographic appliances acquired.

It was decided to carry an aeroplane or seaplane to assist in aerial observations and to be used as the " eyes " of the expedition in the South. There were obvious difficulties in the way of extreme cold and lack of adequate accommodation, but it was thought that they could be overcome.

The ship purchased for the original Northern Expedition was the *Focal*, a small wooden vessel of 125 tons. She was built in Norway, fitted with compound auxiliary steam engines of 120 h.p. She was designed originally for sealing in Arctic waters. The hull was strongly made and the timbers were supported by wooden beams of enormous strength with natural bends. The bow was of solid oak, sheathed with steel. Her length was 111 feet, beam 23 feet, and her sides were 2 feet thick. Her draught was 9 feet forward and 14 feet aft. She was ketch rigged and reputed to be able to steam at 7 knots in still water and to do the same with sail only in favourable winds.

At the happy suggestion of Lady Shackleton she was re-named the *Quest*. She was brought to Southampton in March 1921, and placed in the shipyard for extensive alterations. The work was greatly impeded by the strike of shipworkers, the general coal strike which occurred at that time, and by difficulties generally with labour which was then passing through a critical period. Shackleton had decided to substitute internal combustion engines for the steam engines, but this had to be abandoned, and the old ones were retained. The bunker space was readjusted at the expense of the forehold, allowing a carrying capacity of 120 tons of coal, and giving a steaming radius which with economy and use of sail was estimated at from 4000 to 5000 miles.

It was at this stage that it became necessary to alter the plans of the expedition, and Shackleton realized that the *Quest* which had been considered suitable for the northern scheme was not so well adapted for the cruise in southern waters. It was impossible to change the ship, but alterations were made on deck and in the rigging generally to adapt her for her new conditions.

Two yards were fitted to the foremast: a topsail yard 39 feet in length and a foreyard, to carry a large squaresail, 42 feet in length. The mizzen mast was lengthened to give a greater clearance for the wireless aerials. The existing bridge was enlarged, carried across the full breadth of the ship, and totally enclosed with windows of Triplex glass. The roof formed an upper bridge open to the air. To improve accommodation a deckhouse 12 feet by 24 feet was erected on the foredeck. It contained five rooms: four small cabins and a room for housing hydrographical and meteorological instruments. New canvas and running gear was fitted throughout and no expense spared to make

her sound and seaworthy, this being a point on which Mr. Rowett was absolutely insistent.

Shackleton as an experienced seaman gave his personal attention to the deck work generally. The work of the engine room which he was unable to personally supervise was entrusted to a consulting engineer.

The ship though sound was small and living quarters were somewhat cramped. The forecastle was fitted as a small biological laboratory and geological work-room. In it were a bench and shelves for the naturalist and numerous cupboards for the storing of specimens. Leading from it on one side was a small cabin with two bunks for the naturalist and photographer respectively, and on the other the photographic dark-room.

The amount of gear was large and the greatest ingenuity was required to stow it satisfactorily. Two wireless rotary spark transmission and continuous wave sets of naval pattern were installed. The current for them was supplied by two generators, one a steam dynamo producing 220 volts and the other a paraffin motor producing 110 volts. The *Quest* being a wooden vessel there was great difficulty in obtaining a suitable "earth." For this purpose two copper plates were attached on either side of the ship below the water-line.

The 220-volt set was never satisfactory, and at South Georgia on the outward trip we abandoned its use. The smaller proved entirely satisfactory for transmitting at distances up to 250 miles. We received Greenwich Mean Time signals on many occasions and were thus enabled to check our chronometers. In those high latitudes atmospheric conditions interfered largely with the clarity of sounds by producing adventitious noises in the earpiece.

A Sperry gyroscopic compass was installed, the gyroscopic apparatus being in the deckhouse with repeaters in the enclosed bridge and on the upper bridge. The repeater dials were luminous for reading at night. Bumping the ship through ice caused derangement, and as the compass took approximately six hours to settle again to normal it proved ineffectual whilst in the Pack. I had hoped that Worsley and Jeffrey, the navigators, would be able to make continuous comparisons with the standard compass, but shortage of fuel prevented its general use.

In front of the enclosed bridge we had two Kent clear-view screens. They proved when running to be absolutely effective against rain, snow, or spray. Always when navigation was difficult I had all the windows thrown open, or navigated from the upper bridge. The ship was fitted with electric lighting, including the navigating lights. Whilst in the South the necessity for economy of fuel forbade their use, and we had recourse to oil lamps. Two sounding machines were installed. One was an electrically driven Kelvin apparatus for depths up to 300 fathoms, with sinker fitted to carry sounding tubes. This permitted the taking of accurate soundings whilst the ship was under way. Wax was used for indicating the nature of the bottom, *i.e.* sand, shingle, or rock.

Marr Naisbitt Ross McLeod Dell Argles Young Watts Carr

Worsley McIlroy Wild Green Smith Kerr Jeffrey Macklin Douglas

THE SHIP'S COMPANY

SAINT PAUL ROCKS

SAINT PAUL ROCKS

For deep-sea work we had a Lucas steam-driven machine which was affixed to a special platform on the port bow, and supplied by a flexible tube from the steam pipe feeding the forward winch. This registered depths to 4 miles. Sounding with it was often difficult on account of swell and the liveliness of the *Quest*, but the machine itself gave every satisfaction. The wire used was Brunton wire in coils of 6000 fathoms, diameter 0·028, weight 12·3 lbs. per 1000 fathoms, with a breaking strain of 600 lbs. This wire was used also for the kites and proved satisfactory. The meteorological equipment included: screens containing wet and dry bulb thermometers, placed in exposed positions on the upper bridge; one large screen containing hair-hydrograph, standard thermometer and thermograph; hydrometers for determining the specific gravity of sea-water, which gives a measure of total salinity; sea thermometers for determining the surface temperatures of the sea-water; marine pattern mercury barometer; aneroid barometer checked daily from the mercury barometer in case the latter should be broken; barograph to obtain continuous records of the air pressure.

For upper air work four cylinders of hydrogen and several hundred balloons were taken (these were sent up on many occasions from the ship, but the *Quest* proved to be so lively that it was impossible to keep them in the field of view of a telescope or even of field glasses).

All the instruments were very kindly lent to us by the Air Ministry, and were of standard make and pattern.

We carried a good set of sextants, theodolites, dip circles, and other instruments of precision. We had chronometers of several makes and patterns. We were able frequently to check them, and some of them gave a remarkably even rating in spite of the violent motion of the ship and the difficulty of maintaining an even temperature. Medical equipment was designed for compactness and general usefulness. Sledges, harness, warm clothing, footgear and an additional amount of scientific equipment were sent to Cape Town, and were housed to await the arrival of the *Quest*.

The greatest difficulty was experienced in the housing of the sea-plane, but after dismantling wings and floats, room was eventually found for it in the port alleyway which it almost completely filled.

The following is a list of the ship's company:—

| | |
|---|---|
| Sir Ernest Shackleton, C.V.O. | Died in South Georgia. |
| Frank Wild, C.B.E. | Commander. |
| F. A. Worsley, D.S.O., O.B.E., R.D., R.N.R. | Hydrographer and sailing master. |
| J. A. McIlroy, M.R.C.S., L.R.C.P. | Surgeon and meteorologist. |
| L. D. A. Hussey, B.SC. | Meteorologist and assistant surgeon. |

| | |
|---|---|
| A. J. Kerr | Chief engineer. |
| D. G. Jeffrey, D.S.O., R.N.R. | Navigator. |
| A. H. Macklin, O.B.E., M.C., M.D. | Surgeon, in charge of stores and equipment. |
| G. H. Wilkins, M.C. | Naturalist. |
| G. V. Douglas, M.C., M.SC. | Geologist. |
| C. E. Smith | Second engineer. |
| C. R. Carr | Aviator. |
| J. W. Dell | Chief electrician. |
| Harold Watts | Wireless telegraphist. |
| T. F. McLeod | A.B. |
| C. J. Green | Cook. |
| J. W. S. Marr | Boy. |
| G. H. Ross | Fireman. |
| S. S. Young | Fireman. |
| H. J. Argyles | Fireman. |
| Christopher Naisbitt | Ship's clerk. |

Soon after leaving London we encountered heavy weather. The *Quest* proved to be a very lively ship with a most disconcerting motion even to the old and tried seamen of the party. Conditions were very uncomfortable, and several of the new hands suffered much from sea-sickness. Mr. Bee Mason the photographer and the Boy Scout Mooney were so incapacitated that they became seriously ill, and were put ashore.

The ship developed engine trouble which caused Sir Ernest Shackleton to make for Lisbon, where we arrived on October 4. Repairs were put in hand at once, but it was not until October 11 that we finally were able to get away. We called at Madeira on the 16th and St. Vincent on October 26. The engines had continued throughout to give trouble, and Kerr reported that extensive repairs and readjustments would be necessary before continuing further.

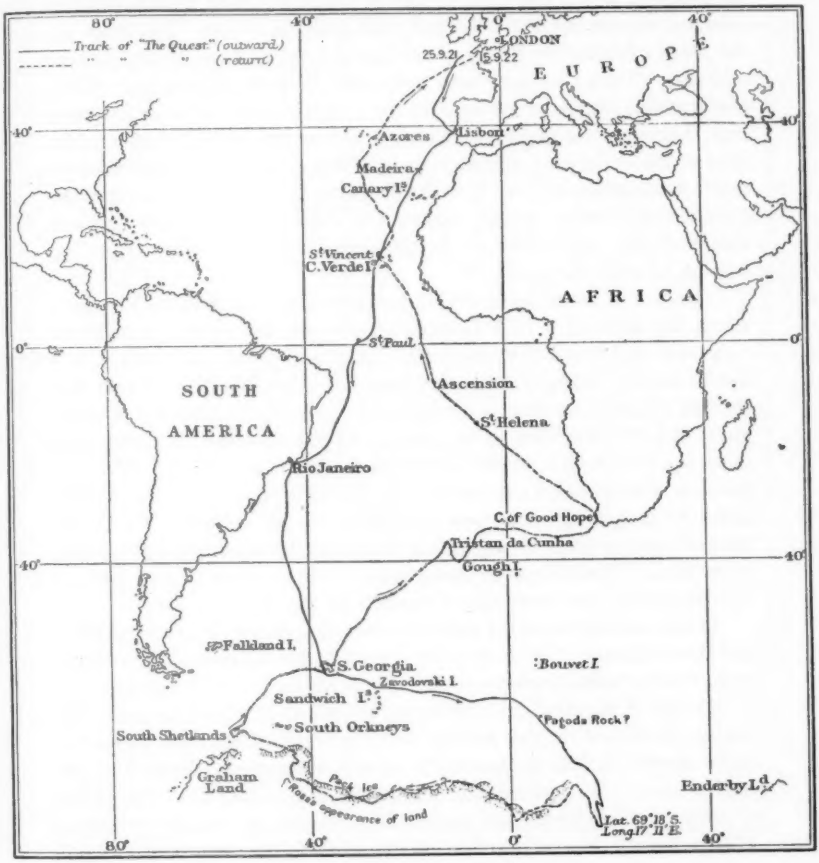
These were carried out, and we hove up and proceeded on October 29. During this time routine meteorological observations were carried out. Hussey made many attempts to get observations of the upper air currents with hydrogen balloons, but even in this fine weather it was impossible to keep them for long in the field of vision.

On November 4 a large school of porpoises came about the ship and played round our bows. We harpooned one and hauled it aboard. Wilkins found in its stomach numerous cuttle-fish beaks. There is a curious superstition amongst British sailors that the flesh of the porpoise is poisonous, though Scandinavians have eaten it for years. We seized this chance of obtaining fresh meat, and enjoyed the change from preserved foods.

In the Doldrums we encountered a beautiful five-masted ship becalmed. She proved to be the *France* of Rouen, the largest of her kind in the

world. She has since become a total wreck on the Great Barrier Reef of Australia.

Early on the morning of November 8 we sighted St. Paul Rocks standing up as a mere speck in the ocean. They were our first objective, and Sir Ernest arranged for a party to land there. We lay-to under their lee and dropped a boat. On approach to the Rocks it was evident




The track of the "Quest."

that a considerable swell was running, and the landing was slightly difficult on account of the heavy wash. Sharks swarmed about the boat. Dr. J. Harvey Pirie of the *Scotia* describes an exciting incident in an attempt to land which had ultimately to be abandoned. We were more fortunate and succeeded in putting a party ashore. Wilkins, assisted by Marr, took camera and cinematograph apparatus and obtained some

excellent pictures of birds. Douglas, assisted by Dell, carried out an accurate survey and examined the rocks geologically. They have been visited by Darwin and Sir James Ross and the scientific staff of the *Challenger*, but on the whole they have been left much alone. They are of great geological interest.

Animal life on the Rocks is composed of two varieties of birds, and landcrabs of which also there seemed to be two varieties, a large reddish-coloured species and a smaller one, dull green in colour. The birds are the Brown Gannet or Booby (*Sula leucogaster*) and the Noddy (*Anous stolidus*). They were very tame and could be easily approached. Their food consists largely of flying-fish, for many of them were so crammed that they were compelled to disgorge before attempting to rise. The food of the crabs also consists largely of flying-fish which have inadvertently flown ashore or been brought by the birds. The crabs are wonderfully active, moving rapidly sideways in either direction, and they are able to jump, which they do by gathering their legs under them and leaping squarely forward.

The cove in the midst of the Rocks teems with marine life. The floor, which lies at from 6 to 8 fathoms at one end and slopes in to about 1 fathom, is covered with seaweed. Sharks of small size, from 2 to 8 feet in length, swarm in large numbers. It was interesting to note that the fish which maintained a certain level seemed to be unafraid of them, but if they left that level, as for instance when we hooked them and drew them up, the sharks turned and went for them in a flash. We were desirous of obtaining a number of fresh fish for food, but had the greatest difficulty in getting them past the sharks to the surface. We at last adopted the expedient of harpooning the sharks, killing them and throwing them back. Their brethren immediately set upon them to tear them to bits, and whilst they were thus distracted we secured some fish.

Before leaving we took a series of soundings, amplifying those existing and showing clearly that at no point is the " hundred-fathom line " distant more than 4 cables from the rocks, and in places is within 100 feet.

We left at nightfall and set course for South Trinidad Island. The engines continued to give trouble, and Sir Ernest Shackleton decided to make direct for Rio de Janeiro to obtain a complete overhaul of the engine room. We entered Rio harbour on November 21. The report of consulting engineers and that of the engineer in charge of Messrs. Wilson Sons & Co. who undertook the work for us, showed that much work was necessary. They condemned the survey which had let her put out on a lengthy voyage. While here an addition was built on to the forward end of the deck house to be used as a mess room.

A month was consumed in this way. It was now impossible to carry out the original programme of visiting the Tristan da Cunha group and making Cape Town our base, and Sir Ernest realized that in order to be able to enter the ice during the open season, it would be necessary to

proceed direct to South Georgia. The aeroplane, all winter equipment, and stores were awaiting us at Cape Town, and we were therefore compelled to go without them.

Sir Ernest realized fully the disabilities under which he would be working without proper clothing and equipment, yet the abandoning of any part of his work never for one moment occurred to him. He hoped

St. Paul Rocks.

that some of Filchner's equipment, which on the return of the *Deutschland* had been stored in South Georgia, might still be available.

We left Rio on December 18 and set course for South Georgia. During this time we had bad weather with some violent gales which tested the seagoing qualities of the *Quest*. Hull and rigging were sound and the vessel showed herself capable of standing anything in the way of seas. Two further developments occurred below decks. A crack

appeared in the furnace from which the water poured out in a thin stream, and the forward water-tank developed a leak and emptied itself. The former was serious, the latter less so, for we could obtain enough water for drinking from the exhaust tank which collected the steam after it had passed through the cylinders. It tasted oily but was sufficient to maintain health, and when put to it one can do without water for other things. In any case even the new hands were by now becoming thoroughly inured to hardship and discomfort.

These developments following each other in quick succession on top of difficulties innumerable since the inception of the Expedition might well have caused Sir Ernest some uneasiness, and must have broken a lesser man. How fully he realized the difficulties of the situation is shown by his last entry: "Anxiety has been probing deeply into me, for until the very end of the year things have gone awry. Engines unreliable; furnace cracked; water short; heavy gales; all that physically can go wrong; but the spirit of all on board is sound and good."

He spoke during the few days before we reached South Georgia of modifications of his original scheme, but reserved any definite decision until a complete examination of the boiler could be made. We arrived at Grytviken on January 4. Sir Ernest wrote before turning in for the night, "Now we must speed all we can, but the prospect is not too bright, for labour is scarce." At 2.50 a.m. on January 5 he died suddenly from heart failure.

This is no place to speak of the work and record of this man, but I wish this appreciation placed on record. I am in the unique position of having served with *all* the British Antarctic Explorers of repute since my first voyage with the *Discovery* and of having an intimate first-hand knowledge of their work in the field. My opinion is that for qualities of leadership, ability to organize, courage in the face of danger, and resource in the overcoming of difficulties, Shackleton stands foremost, and must be ranked as the first explorer of his age.

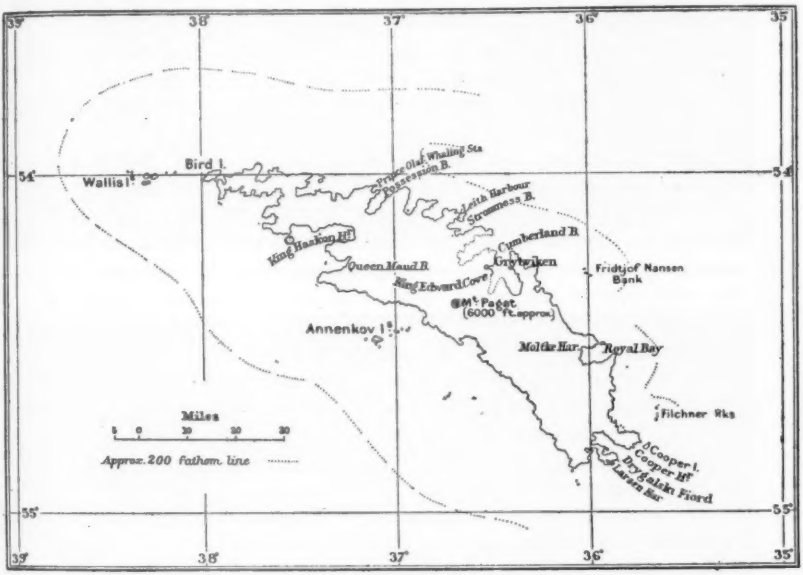
His body was sent to Monte Video, but the wish of Lady Shackleton was that he should be buried in South Georgia, aptly described as the "Gateway of the Antarctic," and he was ultimately laid in the little cemetery on the hillside of Grytviken.

The leadership fell on my shoulders. A short review of the situation is necessary: I had a ship of which the recent gales had shown that hull and rigging were sound and good. The engines had given so much trouble that I could only regard them as unreliable. The boiler was cracked and leaking, and reference to the Norwegian *Veritas* showed that it was thirty-one years old. Under the best conditions speed and driving power were low. The forward (main) water-tank was faulty. I had no proper winter equipment, warm clothing, or sledging gear—

they were at Cape Town. Filchner's store had been broken up and nothing of his was available. The season was late, and the chances of being beset were therefore greater. I had not sufficient stores to justify my wintering the ship, which was in other ways unsuitable. But I knew that Sir Ernest Shackleton would have found some way to carry on, and I decided that by hook or by crook I would carry on also.

The Norwegian managers of the whaling stations threw open their resources, which were limited, but I obtained clothes from the slop chests and food stores of a kind. Their help was invaluable to me.

One of the greatest factors which impelled me forward was that we




South Georgia.

were under the eyes of members of a country which has taken a great part in Polar exploration, and I thought that to deviate from our plans was incompatible with British *prestige*.

We left South Georgia on January 17. Whilst preparations were in progress scientific work and observations were being actively carried on. Douglas and Wilkins had preceded us here from Rio in an oil transport, and they continued throughout to make examinations and collections in geology and natural history respectively. We proceeded first to Cooper Bay to pick up Douglas and Carr, who were there. We took also a fresh supply of seal and penguin meat, and a number of skua gulls. I relied largely on the regular consumption of fresh meat to maintain the health of my party.

From there we passed on to Larsen Harbour, where I set the scientists ashore. Douglas reported having seen a volcano in eruption in the direction of Clark Rocks. I was anxious therefore to visit them, but the next day being thick and misty and the season being advanced I did not delay but pushed on. I intended first to visit Bouvet Island, passing Zavodovski *en route*, and then push south.

On leaving South Georgia we entered a sea filled with innumerable bergs, which passed slowly in a north-easterly direction. Many of them were the usual flat-topped Antarctic bergs, others were old structures of beautiful shape. All were moving to meet their fate in the warmer northern waters.

We reached Zavodovski on January 20. Numerous bergs with distinct tide-marks and much worn at sea-level had gone aground about it. They were thickly covered with Ringed Penguins. Some of these bergs carrying penguins were steep-sided, and there was a heavy wash of water against them. I was struck, as I have so often been, by the patience and tenacity of these little creatures, as they failed time after time to effect a landing, only to try and try till they succeeded.

This island takes its name, according to Dr. H. R. Mill, from Lieut. Zavodovski, chief officer of the *Vostok*, who landed here during Bellingshausen's expedition in 1820. It is barren and snow-covered except on the north-western side, which presents an unattractive bare surface of rock. Bellingshausen described this bare surface as being warm from volcanic action, and says that the penguins found it an attractive nesting-place. On that occasion the island presented the appearance of an active volcano, with thick clouds of steam belching from its summit. Owing to low-lying mist we were unable to see the top of the island, so were unable to gauge accurately its height, but from general contour it appeared to be not more than 3500 feet.

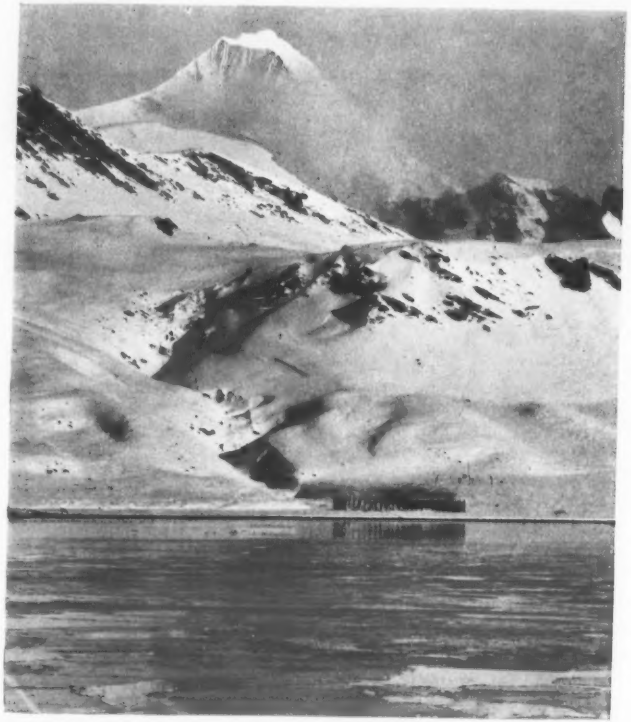
The coast-line presents a rugged face of rock broken here and there by glaciers which finish abruptly above narrow beaches of black sand. A red line of volcanic staining surrounds the island. Possible landing-places exist, but generally speaking it is inaccessible. There are no good anchorages for a ship.

King penguins occupied the small sand beaches and the lower slopes were covered by enormous rookeries of Ringed penguins.

On the south-eastern and eastern sides were caves from which sulphurous fumes were issuing in a thin reddish cloud. We could feel their effects in a smarting sensation of the eyes, nose, and throat. The penguins gave these caves a wide berth, and kept to windward of them. Larsen, who attempted to land in 1908, was overcome by the fumes and rendered seriously ill. For future exploration of volcanic islands the box respirator (army pattern) might well be added to the equipment. We made a running survey and took a series of soundings about the islands.

PRINCE OLAF WHALING STATION

GRYTVIKEN WHALING STATION



SHACKLETON'S GRAVE ON THE SLOPE BEHIND THE BUILDINGS

THE CAIRN ERECTED TO THE MEMORY OF SHACKLETON

We had bad weather nearly all the time we were in the ice region, and life on board was uncomfortable. We were accompanied on this stage of the trip by numerous seabirds, which tailed in our wake in hundreds. They included every species known to these regions, from the large and stately "wandering albatross" to the dainty ubiquitous "Mother Carey's chickens."

On January 24 it became clear to me that I could not hope to reach Bouvet Island and be able to enter the ice this year, so I was reluctantly compelled to cut it out of my programme, and altered course to enter the ice somewhere about 20° E. long.

On January 28, whilst hove-to for taking a sounding, a mass of white pultaceous material floated past the ship. Macklin examined some of it microscopically and reported that it was composed of feathers in a state of decomposition. It is hard to account for its presence; I think it may be vomited material from a killer or sea-leopard which has eaten penguins and disgorged the indigestible portion, just as our sledge dogs used to do.

On January 30 we had a fine day, though a long broad swell continued to run from the westward. I decided to take this chance and swing out the port lifeboat both in order to have her more ready to lower away and to give us a little more sorely needed space on the bridge deck. The boat contained a quantity of emergency stores and was very heavy. The *Quest* rolled considerably, and during the operation a guy parted and the boat swinging forward pinned Worsley against the after bulkhead of the bridge house, almost crushing him to death. For two or three days the surgeons had doubts of his recovery, but once over the shock he rapidly regained his health.

On this day we reached the charted position of Pagoda Rock, about which we made a traversing cruise. A sounding in the position gave 2980 fathoms. It was first reported by Lieut. T. E. L. Moore of the *Pagoda* in 1845, as follows: "In the afternoon of 30 January 1845 we fell in with a most singular rock or rock on an iceberg; it appeared to be a mass of rock about 1600 tons; the top was covered with ice and did not appear to have any visible motion, with a heavy sea beating over it. It had a tide mark round it. We tried for soundings with 200 fathoms, and the first time we fancied we had struck ground, but before we could try again we had drifted some distance off. We could not send a boat or beat the ship up against the breeze that was then blowing."

It is rather remarkable that towards evening when we had set off once more on our course we saw a curious-looking berg, dark green in colour and heavily stained with some earthy material. We altered course to examine it carefully. It was an old weather-beaten berg which had evidently capsized. Our meeting with it here is a curious coincidence.

On February 4, in lat. 65° 7′ S. and 15° 21′ E. long., we encountered and entered pack, when I made my course due south. The pack edge was not well defined, but consisted of long streamers of loosely packed

THE CAIRN ERECTED TO THE MEMORY OF SHACKLETON

SHACKLETON'S GRAVE ON THE SLOPE BEHIND THE BUILDINGS

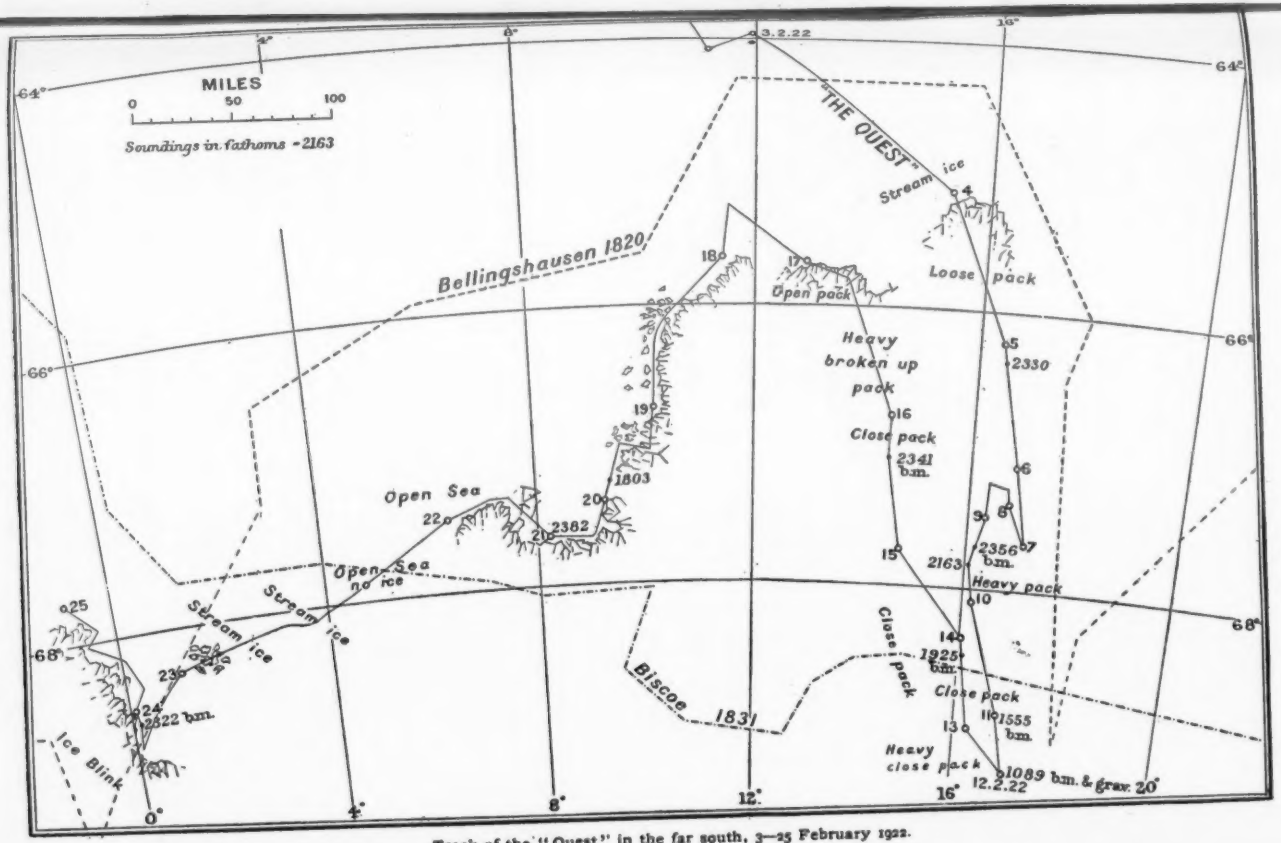
ice, stretching in a north-east and south-westerly direction. Before we had proceeded many miles we met heavier pieces, many of them stained with diatoms. Crab-eater seals were present in considerable numbers, and in the large open leads we saw killers.

On the 5th the floes were much heavier and at times it was all the *Quest* could do to push ahead. I started taking occasional seals both for food and to enable us to eke out the coal supply by judicious use of blubber. It is a messy form of fuel and burns with a fierce hot flame which tends to burn out the fire bars. Except in cases of necessity I do not recommend its use. Crab-eater meat is excellent to eat and is capable of maintaining health for long periods. It is curious that on the *Discovery* Expedition instructions were issued always to take Weddell seal meat in preference to this. The Crab-eater is a much cleaner animal than the Weddell, which is much parasite-infested and has usually an unpleasant toxic smell, and often contains diseased organs. This is due to the difference of feeding. The Weddell hugs the land and lives largely on fish which are a prolific source of intestinal parasite. The Crab-eater, as its name implies, lives largely on the small crustaceæ of these regions, *euphausiæ* and *amphipods*. The best meat comes from the back and the undercut. The brain is a great delicacy. The internal organs, kidney, liver, etc., should be " censored " before being passed to the cook, and if there are any doubtful signs they should be condemned.

On February 7 we entered a *cul-de-sac*, where I lay for twenty-four hours, but from which we had to retreat to the north. After returning about 45 miles in direction north-north-west we again met loose pack and open leads which allowed us to push south, and by noon on the 9th we were only 11 miles north of our turning-back position. The temperature fell and the weather became fair—a bad sign in the pack.

The 10th was a beautiful day, but the prospect to the south was bad—dense and closely packed ice through which we dodged and wriggled with the utmost difficulty. About twenty Crab-eater seals followed us. In the water they are wonderfully graceful. Something on the ship's side had attracted them, and whenever we were held up they rose out of the water to nibble at it.

The seal is probably a much more intelligent animal than it appears to be when on a floe. An examination of its brain shows that the cerebral portions, *i.e.* the thinking part of the brain, are comparatively highly developed. A comparison with the brain, for example, of a shark shows a marked and interesting difference. In the shark it is small and ill developed with the exception of the olfactory lobes, which are larger than all the rest of the brain put together. The centres for sight are small. The seal's brain much more closely approaches the human brain in type and development. Macklin made observations which show that the apparatus for warming the air inhaled is very highly developed in the seal tribe. " The turbinate bones instead of being small and




Track of the "Quest" in the far south, 3—25 February 1922.

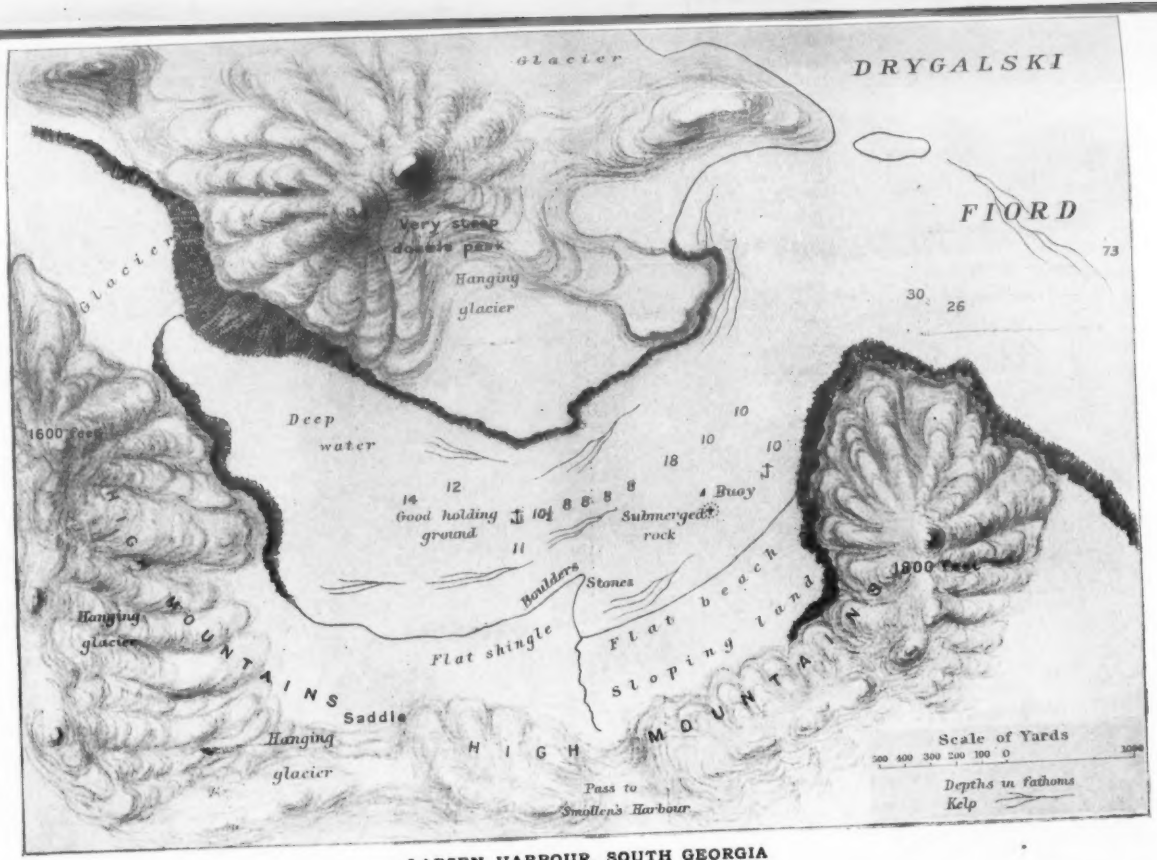
covered by a uniform membrane containing blood-vessels are larger and composed of bars like a radiator covered with a rugose membrane so designed as to give the largest possible warming surface. The function is obvious, for they rise after a period below water to exhale violently and inhale a great rush of ice-cold air, which, if taken unwarmed to the lungs, would have a much greater cooling effect than would be beneficial to a warm-blooded animal." He made also a number of pathological and physiological observations on all forms of animal life. Wilkins collected a number of seals' skins showing particularly heavy scarring, for sending to museums.

I pushed south energetically, but met all the time heavier and heavier pack. February 10 showed a sounding of 2163 fathoms in position lat. 68° 3′ S. and 16° 12′ E. long. On February 11 we obtained 1555 fathoms in lat. 68° 52′ S. and 16° 55′ E. long. On the 12th the air temperature fell to 14° F., the leads started to freeze over, and everywhere the outlook was bad. From the crow's nest ice stretched to the southward, heavy and close packed as far as the eye could see. The sky in that direction had a hard white look. I saw no sign of land. Bird and animal life were markedly absent—a few Emperor penguins, one or two Crab-eaters, and an occasional Antarctic petrel were all that could be seen.

We were held up absolutely in lat. 69° 17′ S. and 17° 9′ E. long. A sounding gave 1089 fathoms, which gives a shoaling of 466 fathoms in 29 miles. These soundings were all taken under Worsley's immediate supervision. I remained for twelve hours in the hope of a change—a rise of temperature and movement of the ice. I put all hands on to the ice—the scientists for magnetic work and to verify our position by theodolite; the others "watered" ship from solid pieces of blue floe.

Towards midnight I decided I must turn back. The sea all round was now frozen solid, so that there was no open water. No ship yet made could have made any impression in the ice to the south of us, and I saw that if I was to escape being beset I must push energetically north; and indeed the outlook in that direction was unpromising. After a vigorous effort we reached safety on February 15.

By noon on the 17th we were clear of pack. We turned to the west, and skirted loose pieces of floe. Early on the 18th conditions looked promising, and we turned south in another attempt to push through to land. By noon we again encountered heavy pack, and were compelled to turn south-west, when we met with heavy weather and solid old floes worn at sea-level so that they resembled gigantic mushrooms growing from the surface. We continued to push south till the night of the 20th, when we met impenetrable pack and had to turn west, making an average course of from west to west-south-west till on the 23rd, seeing more open ice and deep black "water sky" to the southward, I turned in that direction. Owing to failing light I was compelled to lie to for three




LARSEN HARBOUR, SOUTH GEORGIA

NORTHERN SIDE OF DRYGALSKI FIORD

LARSEN HARBOUR, SOUTH GEORGIA

hours at night, and to economize coal I let steam fall off. We were surrounded by a number of large old floes, which owing to the swell gave us some severe bumps, and scored many deep scars in the sheathing. We continued at daybreak, but by noon we were held up by dense impenetrable pack. To the southward as far as the eye could see there was heavy pack, and the sky had a strong "ice blink." It was disappointing. I had now to weigh up the situation, and decided that I could not make another attempt to push south that year. I resolved to make for the charted position of Ross's Appearance of Land.

On February 28 I was compelled, owing to the light and unballasted state of the ship due to depleted bunkers, to have all heavy deck gear stowed below.

We worked our way westwards encountering very bad weather. There was a continuous heavy swell, which made navigation amongst the floes a hazardous matter. The *Quest* rolled incessantly, and the decks were covered in snow and frozen rime. Work aloft was a dangerous undertaking which had to be carried out with care. This was a period which required all our fortitude and endurance. We had four hours' darkness each night.

On March 10 we encountered heavy ice and were compelled to take a north-easterly direction. The temperature dropped to 17° F. We encountered many Adelie penguins. On the 11th and 12th we had strong winds and snow squalls, which made navigation difficult owing to poor visibility. We pushed on through pack composed of heavy old Weddell Sea floes, with the water in between freezing solidly. On the night of the 12th-13th we were compelled by darkness to lie-to. The sea froze solidly about the ship and she was beset. At daybreak we succeeded, after an effort, in breaking free. I spent long hours with Worsley at the masthead looking for signs of land. The day cleared beautifully, but we saw no indication of it. Ahead of us the ice stretched thick and solid as far as could be seen. It was useless to push on, so we hove-to for a sounding, which gave 2331 fathoms in lat. 64° 11′ S. and 46° 4′ W. long. This does not indicate proximity of land. The temperature had dropped to 8° F. and the sea was freezing solid. We were in imminent danger of being beset, so I pushed north to try and reach more open pack.

We were now desperately short of fuel, and I decided that we must make every effort to reach Elephant Island and take aboard some blubber. On March 14 we were beset and frozen in. A large berg passed close to us on the 20th. It approached from the southward and charged relentlessly through the smaller floe at about 2 knots, leaving a lane of open water behind it. It was a remarkable sight. In the evening the temperature rose to 14·5° F. On the 21st after a very hard effort we succeeded in breaking out, and I pushed north entering a more and more open sea. Heavy gales on the 22nd and 23rd, with driving snow

which covered the ship with a thick coating of ice, compelled me to heave-to. About midnight on the 24th it moderated, and we set off for Elephant and Clarence Islands.

At noon on the 28th the islands showed up. The evening was fine and there was a wonderful mirage. Looking to the south-west we saw a number of large icebergs poised in a sky of the purest gold, whilst all about and in between them were numerous whales spouting. These mirages are common about here, but this was particularly wonderful. The sun sank with a peculiar effect. Both Elephant and Clarence Islands seemed to be afire, a rosy glare rising from each of them to the sky. Over Cape Wild lay a reddish golden glow, and the whole appearance of the island was beautiful, giving an impression of the most peaceful calm, a condition very foreign to Elephant Island.

We set course to pass between the two islands and along the south-east side of Elephant Island. During the night we kept a safe margin between ourselves and the shore, but with the advent of daylight we stood in more closely and kept a sharp look-out for a suitable landing-place. On the south-east side there are none, the coast being composed of high steeply-rising rock faces and glaciers, some of which were of immense size.

At Cape Look-out we discovered a small spit which with the wind from the north-north-west offered a lee. We anchored in 5 fathoms and effected a landing. We killed seven sea-elephants. We saw hundreds. The report implying that we had slaughtered all the sea-elephants on Elephant Island and which led to a protest by the officials of the Natural History Museum, is therefore totally unfounded. I am sorry that the information was not confirmed before the report was published, for I doubt if there is in the world a greater lover of animals and animal life generally than myself, and I believe that all explorers have similar sympathies, for I have never in all my expeditions seen a case of wanton slaughter. I must add that if it were a case of the saving of lives of men under my charge I would unhesitatingly kill the last sea-elephant in the Southern Seas—if I could catch it.

In addition to the sea-elephants on the spit there were Weddell seals, ringed and gentoo penguins which formed two separate and distinct camps, one at the outer end and one at the inner end of the spit, paddy birds (*Chionis alba*), blue-eyed shags, Dominican gulls, skua gulls and Cape pigeons. The spit was covered with large boulders and pieces of glacier ice, which showed that it was at times sea swept. A curious incident occurred here. I gave orders whilst the flensing was in process that a dozen penguins should be killed for food. One gentoo taking fright splashed through a pool of blood and came out with white waistcoat dyed a vivid red. He went to rejoin his fellows, but was driven off by vicious pecks and ultimately went off to stand alone. Watts, the wireless operator, catching sight of it, exclaimed, "Look, a new species!" Taking

pity on its outcast condition I drove it into the water, from which it emerged once more a normal penguin to be received this time without comment by his friends. Towards night the wind came more southerly, and a swell running strongly into the anchorage compelled me to put to sea.

There is a large number of outlying rocks off the western coast, and we stood well out to avoid them. On the morning of the 27th I headed in for the north-western point to look for the *Table Bay* reported by whalers. There was no sign of it. Cruising along the coast in a north-easterly direction we sighted a narrow beach at the foot of high rock faces. I landed a surveying party. At nightfall I continued in the hope of visiting Cape Wild. The wind blowing strongly from the west-north-west compelled me to seek shelter in the lee of Seal Rocks, which we approached from the south, feeling our way carefully with the hand lead.

During the night the wind increased to gale force, and coming from direction south-west by south drove us away from Seal Rocks. We narrowly escaped destruction, for the islets are surrounded by numerous submerged rocks and ledges.

The gale increased in violence so that we were compelled to run before it. As it was fair for South Georgia I decided to make the most of it. Heavy seas coming aboard inflicted considerable damage and flooding ward room and cabin made conditions uncomfortable. We entered Leith Harbour in South Georgia at daybreak on April 6.

At South Georgia we refitted, completed repairs, and took aboard mails for Tristan da Cunha, which had been left there. Douglas and Wilkins actively carried on their scientific work in their respective fields. Worsley and Jeffrey surveyed the island and verified the position of the more salient points. Jeffrey took tidal observations. A series of soundings was carried out about the island. Wilkins discovered the nest and egg of the brown mollymauk. Numerous collections were made for presentation to the museums. I gave the hands all the time possible ashore to take walks, play football, and exercise generally after their long cramping spell of ship board. I filled up the bunkers with coal at Prince Olaf Whaling Station.

On May 2 we proceeded to Grytviken Harbour to erect a monument to the memory of Sir Ernest Shackleton. This took the form of a cairn surmounted by a cross. It is situated on an outstanding bluff at the base of Duse Fell close to the entrance of Grytviken Harbour. The poles set up to mark the north and south direction by members of the *Endurance* Expedition still stand, and we found that they had not moved and were in accurate position.

On May 8 we visited Royal Bay and Moltke Harbour, chiefly for geological purposes. I took this chance of taking up a large supply of fresh fish and seal and penguin meat. Worsley carried out a series of

soundings, and we set off the same night. Bad weather dogged us till leaving the Roaring Forties we had lighter winds and milder temperatures. We sighted Inaccessible Island standing out as a dark mass at midnight on May 19-20.

We came to anchor off the settlement of Tristan da Cunha early the next morning.

We found the people very destitute. They are dependent for many of their essentials upon trade with passing ships, which in the days when sailing ships were making the Australian passage and when whaling was being actively carried out in the waters about the island, enabled them to live comfortably. With the departure of the sailing ship in favour of steam and the abandoning of the whaling industry, this trade has languished and almost died. One month before we arrived a Japanese steamer called to drop a missionary and his wife, the Rev. and Mrs. Martin Rogers. This was the first vessel for eighteen months. Her captain refused to trade or to give the islanders anything except a packet of postcards, each of which contained a highly impressionistic view of Fujiyama. I handed out the mails and in Mr. Rowett's name gave them a quantity of stores, also much useful material, of which they stood in great need. I sent Dr. Macklin ashore to learn what he could of the islanders, their ways and customs, and he has written a full account which will be published very soon.

During the short time we remained Worsley and Jeffrey made a survey and verified the position of the northern side of the island. McIlroy interviewed Mr. Rogers and instructed him in the taking of meteorological observations. Douglas ascended to the peak for geological purposes, and Wilkins took numerous photographs of the people. Mr. Rogers had instituted a troop of Boy Scouts, and Marr presented to them a flag specially sent by Sir Robert Baden-Powell for the purpose.

I left at nightfall on May 20 for Inaccessible Island, taking with me three of the islanders as pilots and guides. The wind freshened from the north-east and made getting ashore on Inaccessible Island impossible, so I ran for the lee of Nightingale, where a landing was effected on the south-east corner. The island was surveyed and geological and natural history specimens collected. Whilst the landing-party were ashore the ship was surrounded by sharks, of which we caught several.

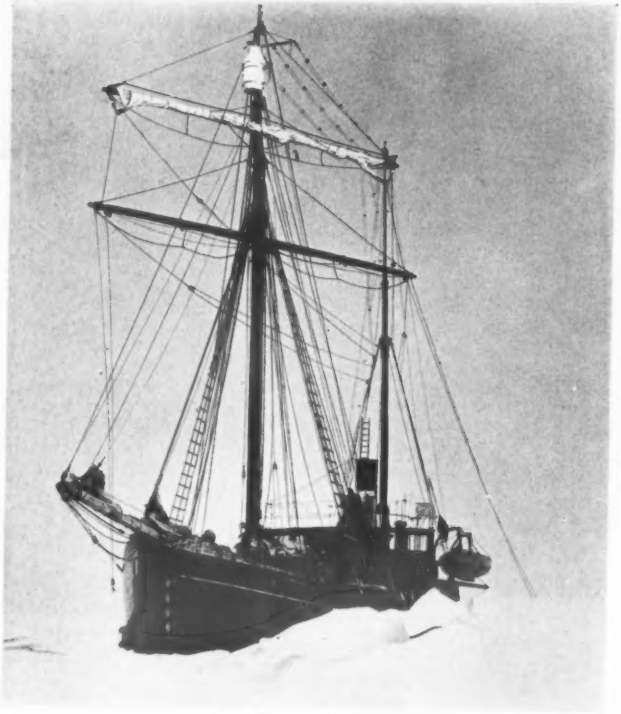
Middle Island was also landed on and examined. Stoltenhoff is inaccessible. Douglas thinks it is an extension of Middle Island to the north, but may possibly represent another centre of volcanic activity. A landing was afterwards effected near the north-east corner of Inaccessible Island. Douglas reached the summit. He describes the interior as "a beautiful landscape of broken country clad in verdure with a stream running through it."

All the islands have a similar flora and fauna. They are covered in parts with tussock grass and bracken. The island tree (*Phylica nitida*)

EVENING IN SOUTH GEORGIA

SOUTH GEORGIA

THE "QUEST" IN THE NORTH-EAST TRADES



THE "QUEST" BESET

grows at levels up to about 3000 feet. The smaller plants include twenty-nine species of flowering plants, and twenty-six ferns and lycopods. Sea-birds include mollymauks, terns, sea-hens or skua gulls, prions, black eaglets, Pediunkers and several kinds of petrel. We saw two species of land-bird, one resembling a finch (*Nesopiza acunhæ*) and the other a thrush (*Nesocichla eremita*). Both were tame and could be easily caught. There are rookeries, deserted whilst we were there, where Rockhoppers congregate in numbers during the season.

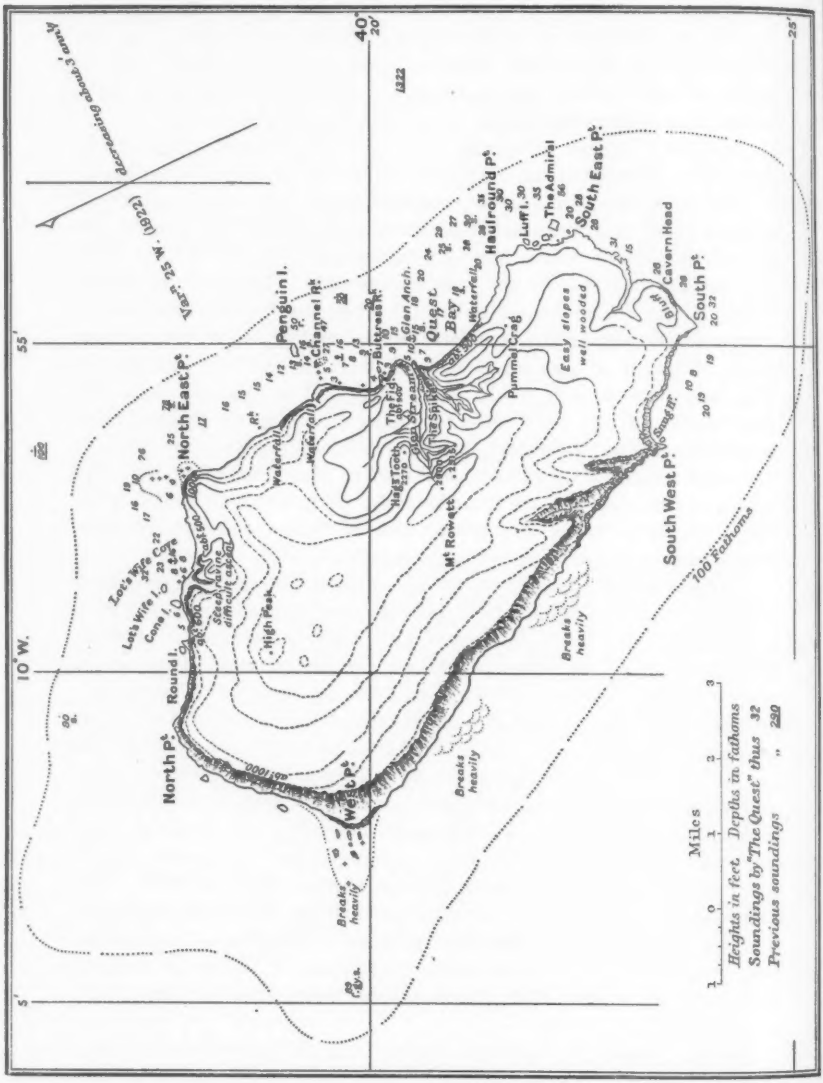
Macklin's account of Tristan da Cunha is too long for insertion in full. The majority of the people are white, but some showed signs of a coloured ancestry in a dusky complexion and features of a distinctly negroid type. The boats are ingenious pieces of work, being made like the old coracles of canvas and skin over a framework of wood. They are however very shapely and built on fine lines. The total population is 137. The settlement somewhat resembles an Irish village, and is composed of about twenty completed houses, and several which have not been completed on account of lack of wood to form the roof beams. The insides are usually divided into living and bed-rooms. Rats and fleas swarm. Crops are limited to potatoes, nothing else being grown in useful quantity. Live-stock includes cattle, sheep, pigs, geese, poultry, and there are also a few donkeys and dogs of a very mongrel type. The people are healthy and are remarkable for their longevity, which is no doubt due to germ-free atmosphere, lack of alcohol and tobacco, pure food, and the open-air life they are compelled to lead.

They have now no headman, no laws, no taxes, no gaol and no police. They seem to get along very well, and live together as a large family with sundry bickerings but no bad quarrelling. Morals are good. 'Sailing Directions' casts an unfair stigma on their characters. They are a prolific people and families of six or seven are general. The women apparently have no difficulties at childbirth. There is one old midwife, who has the peculiarity of having two thumbs on each hand. She adopts the policy of leaving things to Nature. They are closely intermarried, and it has been reported that there are signs of mental and physical degeneration as a result. Investigation shows that this is not correct, but that on the other hand the people are particularly strong and hardy.

It is a pity that this little community is left so much to itself. The arrival of the missionary is a boon to the islanders, for he has instituted a school; the boys and girls attending range in age from about four to forty years. The value of a permanent mission in Tristan da Cunha, with a change of missionary say every three years, would be very great.

We left Tristan da Cunha on May 25 and arrived at Gough Island at about midday on the 27th. The island is rocky and jagged in outline, and is covered with vegetation of which tussock grass, tree ferns, and island trees were most noticeable. In most places the land rises steeply

from the sea, and numerous waterfalls drop vertically in long cascades The coast is marked with numerous caves and chasms.




We sighted North Point and rounded in turn West Point, South-West Point, South Point, and South-East Point. At no place along this

part of the coast were there good anchorages. Snug Harbour much belies its name, for there is practically no harbour at all. It would offer a lee and a useful anchorage during high westerly winds with no swell from south or west, but it would be necessary to lie much closer in than would be safe for any but the smallest of craft.

We found shelter in the Glen Anchorage on the east coast and dropped anchor in 12 fathoms. Landing, as has been shown by previous visitors, is usually a hazardous undertaking, but I succeeded next day in putting ashore a naturalist's party composed of Wilkins and Marr and a geological party of Douglas, Carr, and Argles, with Naisbitt as cook. They were in charge of Wilkins. The Glen beach is composed of large boulders and the approach is complicated by submerged rocks. A slight amount of protection is given by the "Archway Rock" at the southern end. Here a stream runs into the sea, and it is no doubt its continuous action which has worn the tunnel through the rock.

We found two huts ashore, one of wood and corrugated iron, the other resembling those of Tristan da Cunha, built of stone and roofed with tussock grass. They had evidently been set up by a prospecting party, for all about lay instruments for mineralogical examination and cooking utensils. The huts swarmed with mice, evidently introduced by one of the landing parties.

Vegetation was luxuriant. Tussock grass grew everywhere. In between the clumps above the beach and along the side of the stream were numerous sea-elephant wallows. Two young bulls were lying in the stream close to where it enters the sea. There were several clumps of wild celery and ferns of many kinds. The slopes were covered with tree fern, and amongst the smaller varieties was a pretty maidenhair species, of which Jeffrey collected a number with roots for taking home, but which the pig found and ate with relish. There were numbers of island-trees, many of them much larger and thicker than any I saw on Tristan da Cunha.

Thrushes and finches hopped about the beach in numbers. Of sea-birds I saw only skua gulls and terns. From the slopes I heard the "chuck-chuck" of landrail, and later caught glimpses of their bright black bodies, red combs, and yellow legs. I walked up the glen. Foothold was bad, owing to the rocks being covered by a slimy deposit brought from rotting vegetation on the slopes. The water was coloured slightly green by products of vegetable decomposition, but was used for drinking and cooking apparently with no ill effect.

At this time of year there was a great deal of dampness and dank rottenness which took away much of the attractiveness of the vegetation. This is an island where a marooned or shipwrecked party might live in comparative comfort. There is plenty of wood, for in addition to the island-tree there is driftwood on the beach. In addition to the sea-birds, landrails and sea-elephants, the sea swarms with fish, which require only

a bright piece of tin as bait. Crayfish can be caught in quantities. There are large rookeries where rockhoppers nest. They provide excellent meat and their eggs are delicious. Small weatherproof dwellings of the Tristan da Cunha type could be built from stones, and roofed with branches of island trees and tussock grass. Too long a sojourn might produce some of the disquietude of Alexander Selkirk, but at least there would be no fear of starvation!

I put ashore some Tristan da Cunha ganders and geese in the hope that they would settle and breed. Macklin ascended the glen to the Apostle behind. The glen divides into two. The stream in places passes through deep gorges with high smooth walls, and along its course there are numerous waterfalls. The thick vegetation, composed chiefly of island-tree and tussock grass, offers resistance to climbers, but makes possible the passage of steep and otherwise inaccessible places. It forms a belt which ends at a level of about 1500 feet. About this are grassy slopes very wet at this season, composed of grasses and numerous mosses. At this level the air is pure and fresh and cold, contrasting with that in the thick belt which is humid and oppressive.

Wilkins and Marr made a large collection of animal and plant life. Douglas carried out a very active survey and ascended to the top of Mount Rowett, which was found by aneroid to be 2915 feet in height. Douglas also made an interesting observation, finding in the "Little Glen" to the south of Archway Rock a grove of trees "growing as if planted in an orchard," attaining a height of 13 or 14 feet, and covering ground of about 12 feet diameter. It differs in many respects from the "island-tree" (*Phylica*), and Wilkins considered it a species of *Sophora tetraptera*, which is found in New Zealand and parts of South America.

Worsley and Jeffrey made tidal observations, limited in value on account of the shortness of our stay, carried out a careful running survey of the coast, and accurately placed all the more salient points. An examination of the anchorages, one on the north coast, one on the south coast, and two on the east coast, showed that shelter might be found from northerly, southerly, or westerly winds. There are no sheltered bays, each anchorage being an open roadstead. None of them can be considered safe for ships without steam; and they should at all times be prepared to get under way at very short notice. The Glen Anchorage affords good holding ground. Soundings and examinations were made for all dangers and rocks about the coast. There are no outlying dangers about Gough Island.

I took off the shore parties on June 2. Surf made landing at the beach difficult, so I shouted to the party to take their gear to the top of Archway Rock. There is a place at the foot where experienced boatmen can effect a landing in almost any weather. At the corner of the rock nearest the northern end of the beach there is a chimney up which an active man carrying a coil of rope could clamber, and on the top of the

rock are a few island-trees to which it could be secured. In this way landing on and departure from the island can be effected in any but the worst weather, though in the case of moving heavy gear it means very hard work. We got back to the ship without incident.

Leaving the anchorage we proceeded in a north-westerly direction to a sheltered spot close to the high rounded column of " Lot's Wife " and anchored in Lot's Wife's Cove. Worsley, Macklin, Douglas and Wilkins landed. At this point there is a large rockhopper rookery. The salient positions about the cove were established. Wilkins added to his natural history collection, and Macklin climbed the slope to the rocks above to obtain some photographs of the locality.

Early on June 3 we set off to Cape Town, searching *en route* for a reef reported by the whalers at South Georgia as having been seen 350 miles east-north-east of Tristan da Cunha. We saw absolutely no indication of its presence, and three successive soundings gave not less than 1900 fathoms with the same white clay bottom we had found since leaving Gough Island. On the 6th and 7th we made a traversing cruise in a further search.

On the 9th we had a strong gale, in which the *Quest*, depleted of coal and practically of all stores, excelled anything she had ever done in throwing herself about. Sir Ernest Shackleton's dog was washed overboard and drowned.

We reached Cape Town on June 18, when members of the crew fell victims to influenza. The *Quest* had received much damage at the hands of heavy seas and ice, and required overhaul and repair.

We left on July 13 and visited St. Helena, Ascension Island, St. Vincent, and San Miguel in the Azores.

We returned to England on September 16, quietly as was befitting, our homecoming saddened by the loss of the companion whom we had left " down there."

## THE HYDROGRAPHIC WORK

### Commander F. A. Worsley, D.S.O., R.N.R.

THE hydrographic work was carried out by me with the assistance of Lieut.-Commander Jeffrey, R.N.R., J. Dell, P.O. R.N., and Captain G. V. Douglas.

A new large-scale chart was made of St. Paul Rocks and the surrounding submarine plateau within the 100-fathom line, on a scale of 200 feet to the inch: the Admiralty chart 388 being on a scale of 2029 feet to the inch. The position of the centre peak (45 feet) by sextant observations of the Sun from the ship, and bearing and rangefinder distance (600 yards) of the peak, was made to be 0° 56′ N. and 29° 22′ W., or 32″ N. and 32″ E. of the position on Admiralty Chart 388; but as

ours were single observations to the southern and western horizons, the Admiralty position should be the more correct. From their small size (the largest being 380 feet by 180 feet) and the probability that erosion is taking place, it is doubtful if these islands can ever be used for an air station, or for any other purpose than a lighthouse, or wireless meteorological and directional station.

At South Georgia we carried out series of soundings to the south-west, west, and north, discovering several banks, with apparently a fairly clear bottom for trawling in from 50 to 100 fathoms, 10 to 30 miles offshore. We found no indication of a bank at a greater distance to the north-east, as has been reported, but the 100-fathom line is much farther off to the south-west than was expected. From whalers' reports and our soundings, it would appear that there is a more or less continuous bank to the north and north-east of and parallel to the island, with deeper water forming a submarine valley between. With a limited examination we found the bottom mainly a dark grey sand, gravel, and stones.

The whalers report that these banks swarm with an incredible number of very good eating fish—so easily caught that they can be "jigged" up with no bait but a bit of bright metal on the hook. There is a large Roman Catholic population eight days' steam away in South America, and it is possible that a profitable trawling and fish-curing industry could be started here.

We made a sketch-chart of Prinz Olaf Harbour in Possession Bay, where Lever Bros. have a whaling station. This is the best harbour at the west end of South Georgia. Some additions were made to the plan of Stromness Bay, Admiralty Chart No. 3579.

Soundings were taken from Cumberland Bay to Cooper Island. The bottom here is rocky and irregular, with several reefs and dangers, all however fortunately marked by kelp—the great safeguard and aid to navigation around South Georgia—except on the southern and western coasts, where icebergs tear much of the kelp away. The kelp is useless, however, if one is steering towards a bright sun, as the glare on the water makes it impossible to see the kelp soon enough. The S.S. *Fridtjof Nansen* was so wrecked on a reef 7 miles offshore near Cape George in 1907; but the whalers steam full speed straight for the coast in thick fogs, and being very handy, turn in almost their length immediately they see the kelp, which frequently reaches to the surface in 60 fathoms.

A sketch-chart of the passage inside Cooper Island was made, and of the Cooper Bay anchorage for small vessels. A rough chart of Larsen Harbour, the best harbour at the south-east of South Georgia was made. There is enough flat ground here to make a small whaling station, and sufficient water for the factory could be got from the glacier streams.

We took new soundings in Royal Bay, and across the front of the

Great Glacier, steaming along a quarter of a mile inside the line of the glacier front of 1902 (Nordenskjold), but along the line laid down by the German Survey of 1882; showing an advance and then a retreat of the glacier front.

Lastly we sounded from Cooper Island out to and east of Clerke Rocks, and obtained a bearing and sketch of Clerke Rocks, and found their error of position relatively to Cooper Island to be about 10 to 14 miles, but owing to cloudy and foggy weather we could not ascertain the exact amount, or how much of the error was in the Rocks and how much in Cooper Island.

A running survey with soundings was made around Zavodovski, 56° 18′ S., 27° 30′ W., the northernmost island of the Sandwich Group, an inhospitable island with difficult or dangerous landing and still more difficult way up the cliffs of rocks and ice to the upland. The peak unfortunately was hidden by clouds, and no signs of activity of the volcano were seen. No outlying dangers were visible—in several places we got 20 fathoms 100 yards from the shore. On the north side were numerous grounded bergs indicating shoal water. These bergs were about 40 to 50 feet high, which on the basis of 1 fathom below water to 1 foot above would give a depth of 40 to 50 fathoms. On the eastern side we saw faint blue hazy smoke issuing in several places from clefts and caves in the cliffs, and when we got to leeward could distinctly perceive an unpleasant sulphurous smell.

At Elephant Island we made a rough survey of Cape Lookout anchorage, where we anchored and took several soundings south and west of Elephant Island. We anchored at Cape Lindsay (north-west of the island) and Seal Rocks, taking bearings and soundings. None of these anchorages can be described as harbours, and with an onshore breeze they must be left at once. We steamed through the intricate nest of rocks and reefs that stretch for over 20 miles to the west and north-west of Cape Lindsay. This was very ticklish navigation, requiring a close unremitting watch from the crow's nest. There was no warning kelp, the only guides being a brown discoloration under the water and an occasional swirl of the sea.

The existence of Pagoda Rock was practically disproved by a sounding of 2902 fathoms 2 miles east of its reported position. It can with safety be expunged from the chart.

Forty miles north-east of the position assigned to Ross's appearance of land we obtained a sounding of 2446 fathoms blue mud, and could see no land from the masthead with clear weather. It seems improbable, therefore, that it exists, unless it is south or west of the position given. Ross appears to have been working on dead reckoning, and it could not have been far in those directions, or we should have found indications of it during our drift in Shackleton's Expedition of 1914–16.

At Gough Island we determined the position of Penguin Island (on

the east coast) to be 40° 18′ 10″ S. and 9° 54′ 0″ W., which is 2′ 22″ S. and 4′ 6″ E. of the latest Admiralty Chart, but only 50″ N. and 2′ 0″ E. of the Admiralty's previous position. These positions are the mean of a number of solar and stellar observations on different days by sextant from the ship, and bearings and rangefinder distance to Penguin Island; but we were able to use only the northern and eastern horizons.

Our chronometer errors were known absolutely by wireless telegraph time signals. It would be interesting to know if this is the first time that the position of an outlying island like this has been verified by wireless.

The position of Glen Anchorage was also accurately observed, and agreed with the position by Captain Robertson of the S.S. *Scotia* of Bruce's Scottish Expedition. We determined the position of the anchorage in Lot's Wife's Cove, north end of island, by three observations for latitude and one for longitude. We surveyed and sounded two new anchorages, and sounded the southern, eastern, and part of the northern coast.

A new chart of Gough Island, with large and important corrections, on a scale of 1/36,431 was made. The highest point of the island was found by Captain Douglas with an aneroid to be 2915 feet in the centre of the island, not 4380 at the northern part, as previously charted. Very good fish were caught in great abundance in the whole group, and crayfish abound, at Gough Island in particular, to such an extent that it is possible a profitable cannery could be started there.

In February and March 1922 the limits and conditions of the pack ice for 2500 miles from 18° E. to 52° W. between the latitudes of 63°–70° S. were determined. These, compared with Ross's, Biscoe's, Bellingshausen's, and Shackleton's are very interesting, showing the great difference between one year and another, and between one month and another.

In Tristan da Cunha, Gough Island Group, additional information for the Sailing Directions was obtained. Materials and directions were given to Robert Glass at Tristan da Cunha to erect beacons at Falmouth Bay for convenience of the inhabitants when landing in their boats during darkness, and to act as leading marks for a safe anchorage for visiting ships.

We practically disproved the existence of a reef reported by two whaling captains as having been seen by them on voyages from Cape Town to South Georgia in 35° 40′ S. and 5° 20′ W. (350 miles E. by N. of Tristan da Cunha). We steamed over the position and searched for two and a half days in the vicinity, half the time with a heavy southerly gale, in which a breaking reef would show 6 or 7 miles away. We sounded in 1940 fathoms 3 miles south-east from the position given, 1942 fathoms 15 miles east, 1994 fathoms 15 miles south-east, and 1989 fathoms 8 miles to the east, besides four soundings of 240 fathoms no

THE "QUEST" IN CUMBERLAND BAY

PUSHING SOUTH THROUGH HEAVY PACK

THE "QUEST" AT HER FARTHEST SOUTH

THE SETTLEMENT, TRISTAN DA CUNHA

DESCENDANTS OF WILLIAM GLASS, FOUNDER OF THE SETTLEMENT ON TRISTAN DA CUNHA

bottom, and one of 560 fathoms no bottom, at varying distances from 15 miles south-west to 5 miles north-west. I do not think the reef exists; but this instance gives some idea of the time and trouble a survey ship may expend in searching for danger, and then not finding it, through having been given a wrong or doubtful position; but vessels passing this way would be well advised to keep a good look-out for breakers.

Thirty-two soundings were taken in the Southern Ocean, practically all in previously unsounded areas. They were made with a Lucas machine, driven by a small Brotherhood engine, all kindly lent to Sir Ernest Shackleton by the Telegraph Construction and Maintenance Company, who also provided the *Endurance's* Lucas, with which we sounded the Weddell Sea. Our first line of soundings was run from a position 500 miles east of the Sandwich Group to our Farthest South point in 69° 18′ S., 17° 11′ E., where we unfortunately were barred from further progress by heavy impenetrable pack. The soundings here were of great interest, having shoaled from 2356 fathoms to 1089 fathoms in a distance of 100 miles. This, with other indications, made it practically certain that land lay a short distance south, possibly not more than 60 to 70 miles.

An irregular line of soundings for over 2000 miles was then carried from 17° E. to 46° W. mainly within and along the Antarctic Circle. The bottom as usual was mostly blue mud, droppings from icebergs, but north of "Ross's Appearance of Land" we dredged up a large haul of angular rocky fragments, to the joy of the geologist. Very heavy weather unfortunately prevented us sounding the blank area between Elephant Island and South Georgia. Three soundings were taken between South Georgia and Tristan da Cunha, but heavy weather again prevented our doing more. Our last series were taken from 50 miles north of Gough Island to 35° 40′ S. and 5° W., the bottom over this area consisting mainly of globigerina ooze.

Difficulty was experienced at all times in sounding owing to the extraordinary liveliness of the *Quest*, and many more soundings would have been taken but for the slowness of the vessel, lateness of the season, limited time, and bad weather.

A number of heights in the Tristan da Cunha, Gough Island Group, were determined by Captain Douglas with an aneroid; they are mostly in excess on the Admiralty charts.

| | *By Douglas.* | *By Admiralty Chart 2228.* |
|---|---|---|
| Tristan da Cunha ... ... ... | 6400 feet ... | 7640 feet. |
| Middle Island ... ... ... | 200 „ ... | 150 „ |
| Inaccessible Island ... ... ... | 1508 „ ... | 1840 „ |
| Gough Island ... .. ... | 2915 „ ... | 4380 „ |

Our observations, being almost all taken from the ship, were of course by sextants; Jeffrey using a Troughton and Simms, while I used one of Heath's. The maximum error of our observations at Gough

Island would not, I think, be more than 30". We had twelve chronometers, and an old one of Uhrig lent us by the Admiralty gave the best results. In spite of the *Quest's* liveliness all chronometers performed well, and we were able to keep accurate G.M.T. throughout by the wireless telegraph time signals, which were received daily at sea for several periods, and at other times about once a week. The longest time without them was forty days in the Antarctic, where atmospherics interfered very badly; even then the maximum error of our chronometer time was probably under four seconds. Our other appliances were the ordinary Admiralty type of Kelvin sounding machine with a 300-fathom 15-strand wire; a Lucas sounding machine carrying 6000 fathoms of a single fine steel wire (21 S.W.G.); a Sperry gyroscope compass; and two Admiralty rangefinders—one 65 centimetres and one 4 feet 6 inches, both by Barr and Stroud.

The Kelvin machine is intended for soundings to a depth of 100 fathoms while the ship is under weigh; the thin glass tubes coated inside with silver chromate record to 100 fathoms, but we repeatedly took soundings to 280 fathoms by stopping and getting a perpendicular cast. But I think that with modern high-speed conditions there is a great gap in the sounding machines for the Navy, Merchant Service, and survey ships. A motor or hand-driven machine is required carrying 1000 fathoms of a fine five-stranded wire similar to the German pattern used by Bruce in the *Scotia*. The lead should be of a streamline shape, and it would then be possible for a vessel at high speed to obtain a much deeper cast than is now possible, and, by stopping, depths of 1000 fathoms could be obtained.

The 6000-fathom Lucas machine was lent to Sir Ernest Shackleton on his different expeditions, and supplied to the French, German, and Australian Antarctic Expeditions of 1908–1910 and 1911, and to the Canadian Arctic Expedition of 1913. It has done the major part of the work of exploring the profound depths of the World's oceans—is I believe easily the best machine to-day for the work. We also had a 500-fathom Lucas, suitable for boat work, with which I have always hoped at some time to sound, through a crevasse, for the thickness of the great Antarctic ice-sheet. The 6000-fathom machine could also be used for kites, small balloons, and other aerial work.

The Sperry gyroscope compass worked well as far south as we went (69° 17′), but the liveliness of the vessel made the initial adjustments difficult, and the constant ramming and blows from the ice threw it out again. The small size of the vessel did not allow us to carry enough fuel for the actuating dynamo, and the lateness of the season prevented us stopping often for the necessary three or four hours to steady it up. We can however say from our experience that in a slightly steadier vessel, with more time and dynamo fuel, it would be most useful even in latitudes beyond 70°, for quickly ascertaining the variation of the magnetic compass

and in conjunction with the rangefinder, for making a roughly accurate chart of a coast or islands. Much of our survey of Gough Island was so made.

The 65-centimetre Barr and Stroud rangefinder was useful in giving the distances, to lay off the bearings in survey work, and, with vertical angles, for obtaining the heights of peaks, islands, and icebergs. The larger 4 feet 6 inches rangefinder was virtually useless, as we could use it only in a completely land-locked and smooth harbour.

The Naval wireless set (Type 4) lent us by the Admiralty was particularly useful in giving us G.M.T. and so correct longitude. Our reception was very good: when 68° 49′ S. we received time signals from Rio Janeiro at a distance of 3206 miles. Later we heard messages (the signals being loud) from 'Frisco at a distance of about 8600 miles, while in lat. 65° S. and in lat 50° S. we received time signals from Nauen, Germany, 9000 miles distant. The latitude appeared to be a governing factor, as south of lat. 50° S. we experienced very bad atmospherics, while south of lat. 55° S. there appeared to be an almost constant roar in the receivers, making it impossible to read signals, although they could be often heard. There may have been more silent intervals than appeared, as we had only one operator, and, being busy on ship's work, he listened only for half an hour at the appointed time for the signals.

The greatest distance that we transmitted signals was about 400 miles to Cape Colony; normally we could get 200 miles. The wireless telephone with a short wave receiver, lent by Marconi's, worked very well. We spoke over a distance of 100 miles with it approaching Rio, and it was made evident that on any expedition it would be very useful The only difficulty was the loud roar made by the engine, which no doubt could be silenced considerably.

Jeffrey and Douglas, who took the magnetic observations, had only two opportunities to obtain variation and dip. The first in 69° 17′ S. and 17° 9′ E., our farthest south, made the dip by Barrow Dip Circle to be 67° 53′ 45″ and the variation 26° 25′ W. by H.O. compass on the floe, with which the gyro compass agreed. The variation taken from the Admiralty Chart for 1922 was 26° 30′ W. The other observations in 63° 51′ S. 45° 13′ W. gave dip 56° 48′ 36″, variation 8° 30′ E.; the Admiralty Chart gave 6° 30′ E. These observations show that there is not much error in the Admiralty's hypothetical curves in previously unobserved positions.

## THE GEOLOGICAL WORK

### G. Vibert Douglas

THE geological work was confined to the islands which we visited in the Southern and Atlantic Oceans, except that the hydrographer obtained

some oozes and pebbles in soundings within the circle which will be of very great interest.

The work in the Subantarctic on South Georgia and at Elephant Island is perhaps the most important, not only because it was done more thoroughly, but also because attention has been directed recently to this part of the globe by the displacement theory of Wegener.

South Georgia has the appearance of an upland dissected by cirque recession and enlargement. The glacial valleys run in general across the longer axis of the island, and are separated from each other by comb ridges. The glaciers in general show signs of withdrawal.

The retreat and advance of the Ross Glacier shows that the glacier is operating, to use an hydraulic term, under a high head. Being forced out to sea, when the foot is afloat, it continues to advance until the effect of the rollers on the floating mass of ice overcomes the tensile strength of the ice and it breaks away.

Four-fifths of the island of South Georgia is of sedimentary origin, the rocks being tuffs, phyllites, and schists which are found in beds varying in dip from horizontal to vertical. The remaining fifth is composed of an igneous complex with types such as syenites, gabbros, and basalts. It is believed that these igneous rocks are more recent than the sediments.

Very similar in structure to South Georgia is Elephant Island, in the South Shetlands, but here the glaciation has not been carried to such an extent. The interior of this island, as well as of the neighbouring Clarence Island appears to be a high upland covered with an ice-sheet. Few cirques were seen and the glaciers on the west coast were of the hanging type. The rocks are practically all sedimentary, but have been very much metamorphosed. The principal types seen were phyllites, banded limestones, slates, and garnet schist.

The island of Zavodovski is volcanic, and from the ship the flows appeared to consist of a compact columnar basalt at the base, with a layer of rough pohoehoe lava over it. Of the vapour vents in the cliffs, some were lined with scoriæ. There is practically a virgin field of great interest to the naturalist, geographer, and geologist in this group, but offering to any adventurer the most inhospitable aspect that can be conceived.

The structure of Gough Island can best be described as a monoclinal block with dip slopes to the west and steep escarpments to the east. On the east side the escarpments are cut by three or four V-shaped valleys, the largest about the middle of the east side giving access to the interior. The most striking feature looking up this glen is the great stock of an acid intrusive rock which rises to 2270 feet in splintered pinnacles.

The chief country rock is basaltic with considerable variation in texture. Marvellous doleritic dykes cut the basalts. They are very

THE ISLAND TREE (*Phylica nitida*)

INACCESSIBLE ISLAND

DELL ROCKS, NORTH-WEST END OF GLEN BEACH, GOUGH ISLAND

LOT'S WIFE COVE AND CHURCH ROCKS, GOUGH ISLAND

THE GLEN AND ARCHWAY ROCK, GOUGH ISLAND

resistant and stand up prominently, their cross-columnar structure being a special feature.

The island is covered in vegetation and during the summer months is a naturalist's paradise.

Tristan da Cunha rises as a prism for about 2000 feet, above which it ascends as a cone to over 6000 feet. The base is of a hard columnar lava with alternating flows and layers of basalt, agglomerate, scoriae, and cinder. The rainfall on the upper levels is considerable, and the erosion is correspondingly great.

Inaccessible Island to the north is well suited for habitation. It rises abruptly for 600 feet from the sea, and then there is a depression towards the interior. A small cone towards the north-east of the interior rises to 1500 feet. The whole is covered in vegetation—scrub trees, ferns, grasses and mosses. The geology is simple—a series of basalts and trachytes with dykes cutting them.

Middle Island is interesting because some doubt was cast a few years ago on its origin. It would appear that a great mass of agglomerate once extended from Nightingale to the north; into this was intruded a basic stock, followed by minor explosions, as the agglomeritic débris of Middle Island testifies. After this became quiescent the erosive action of the sea wore away the agglomerate, which is soft, and the stock still surrounded by some of this rock, lives to tell the tale of the birth of Middle Island.

Before the paper the PRESIDENT said: We are this evening to be given an account of the voyage of the *Quest* to the Antarctic. The Expedition was the offspring of the restless brain and the adventurous spirit of the late Sir Ernest Shackleton, who was fortunate enough to arouse the interest of an old schoolfellow of his, Mr. Rowett, who has cheerfully shouldered the somewhat heavy financial burden of the Expedition. Mr. Rowett was fortunate in having as second in command of the Expedition Commander Frank Wild, from whose lips you will hear the account of its work. I say "fortunate" because upon Commander Frank Wild, after the much-lamented death of Sir Ernest Shackleton, devolved the task of carrying through the Expedition to a satisfactory issue. And if I may say so, no man could have been better qualified to do so, for he had already had experience of no less than five Polar expeditions.

Other members of the party who should give us short accounts of their experience this evening are Mr. Macklin, the Surgeon to the Expedition; Lieut.-Commander Worsley, Navigating Officer and Hydrographer; and Mr. Douglas, the Geologist.

It is, I think, fitting upon an occasion such as this that I, as your President, should place on record your feelings of admiration for the courage, the enterprise, and the services to the science of geography of the late Sir Ernest Shackleton, whose mortal remains now lie in their lonely grave washed by the waves of the ocean at the gate of the Antarctic. I am sure at the same time you would wish me to offer your hearty congratulations to Commander Frank Wild and the other members of his party upon their safe return and upon the accomplishment of a not inconsiderable volume of work of no small value to the cause of science.

I now ask Commander Frank Wild to give us his account of the voyage of the *Quest*.

*Commander Wild then read the paper printed above, and showed a part of the kinematograph film made on the Expedition; a discussion followed.*

Dr. MACKLIN, who was called upon first, asked permission to give way at once to Commander Worsley.

Commander WORSLEY: The hydrographic work was undertaken by Lieut.-Commander Jeffrey, Captain Douglas, and myself in the intervals between scrubbing decks, loosing and setting sail, and calling the *Quest* names. We surveyed the St. Paul Rocks and Gough Island, Elephant Island, and several harbours in South Georgia—though you cannot call them harbours in Elephant Island; they are places where you can find shelter occasionally. Gough Island we found almost exactly in the old position given by the Admiralty charts and not in the position newly given by the Admiralty, which, I believe, was corrected by the Americans, so we put it back to the old place. Around Gough Island and Tristan da Cunha we found enormous quantities of fish and crawfish in the sea, and very good they were to eat. We used to put down a net about 3 feet broad with a lump of fish or meat in it and with lead at the bottom. After waiting about five minutes we pulled it up and found it full of craw-fish. I think it would be a very good place to start a craw-fish industry. Another great place for fish was on a huge bank of soundings running about 30 miles north of South Georgia, about 70 or 80 miles long, and apparently good ground for trawling on, and the fish were so thick we did not need to bait the hook but merely used a piece of bright metal. They came to see what it was, and we jigged them up head, tail, or any way.

We surveyed a very fine little harbour at the south-east end of South Georgia called Larsen Harbour. It is so good that it would probably be useful, if they find more whales in that direction, as a whaling station. There are no whaling stations at that end of the island. We also surveyed a small anchorage in the back of Elephant Island, the only place you could anchor in, near Cape Lookout. I do not think you want to hear much more about the hydrographic work to-night, but there is one thing Commander Wild did not tell you about, and that was the composition of our party on board. You remember that when Drake went round the world he divided his people up into mariners and gentlemen—a great distinction, of course. So we split up into mariners and gentlemen; and the mariners were, first of all, divided into two classes. One, led more or less by Lieut.-Commander Jeffrey, did not believe in sails at all but in good old steam; the other believed in sails, which Jeffrey always called "relics of barbarism." But they did a good turn in any case. The gentlemen of one watch consisted of men from the Colonies, and they used to say they should not be called Colonials because they came from the Dominions. They were then called Dominials, and ever afterwards dominials, mariners, and gents were our crew. The steering of the ship was difficult. She always used to go over to port like a donkey going up a side street after a bunch of carrots. When the gentlemen got the wheel the navigation was something marvellous.

While on the subject of navigation I would like to say that we get most extraordinary refraction in those parts. On one occasion in the old *Endurance* days the sun had set and gone away altogether. I had taken the sun for the last time and said we would not see it again for ninety days. Then after eight days it got up again. It had gone away 180 minutes and risen by refraction. On other days we watched the sun set all right and come up again and set about five times until we got tired of it.

The proper thing in survey is to use a theodolite, but sailors always use a sextant, and there used to be great rivalry between the advocates of the two instruments. Sometimes our geologist would get out on a floe and I would go with him; he would take a theodolite and I a sextant. At times he was very rude to me, but eventually he found I was as well off as he, because the floe was moving slowly with the swell.

The PRESIDENT: The other loquacious member of the party, Mr. Douglas, the geologist, with becoming modesty has asked to be excused.

Dr. H. R. MILL: After hearing once again an Antarctic Address delivered before this Society I am tempted to say a great deal, but time only permits very little. I wish to make three points which could be expanded if time permitted into a more worthy speech. The first point is that Sir Ernest Shackleton through all his life was passionately devoted to the romance of exploration. At the earliest stage of his first voyage the fascination of the lonely islands of the ocean took a strong hold on his imagination. The first land he sighted when as a boy of sixteen he first left his own shores was the little group of St. Paul Rocks, and these he saw again only on his last voyage at the end of his career. From the beginning he had formed the idea of exploring the oceans in order to visit all the little-known islands and to determine whether the islands that had been reported once and never seen again really existed. He caused a good deal of this exploration to be done in the return of the *Nimrod* from the Antarctic Expedition in 1909. After his war service following on the return of the *Endurance* Expedition he elaborated plans for two alternative expeditions, one to study the little-known islands and make oceanographical observations all round the world, and the other to explore the inaccessible part of the Beaufort Sea in the Arctic Regions. So that when the Beaufort Sea scheme broke down he did not formulate entirely new plans at a moment's notice, but simply reverted to the former of the two alternatives.

The second point I wish to make is that in the history of human friendship there is none that can excel that which existed between the Boss and the Boys, as they called each other. And of all the boys Frank Wild was the one with whom his friendship was the nearest modern equivalent to the friendship of David and Jonathan or of any of the grand unforgotten friendships of classical antiquity. Therefore it was most fitting that the last expedition of Sir Ernest Shackleton, which he had designed and which the generosity of his old schoolfellow at Dulwich College, Mr. Rowett, enabled him to start, should have been carried through by Commander Frank Wild, if not to its full extent, at least to a far greater extent than one could have believed possible considering the short time available for the work to be done. Although it was impossible for Commander Wild to-night to point out the full value of his observations in the Enderby Quadrant, it is extremely significant from the point of view of geographical theory that he found evidence of the existence of land very near the latitude of 69° S. to the south of the Cape of Good Hope. I will not further develop this point, but I am sure that you will all be with me in expressing my feelings of intense admiration for the way in which these gallant men went forth in that little ship, as small a ship as carried the great explorers of the greatest days of our history, perhaps into stormier seas, and came back safely in spite of all the dangers and hardships which they had encountered.

My last point is that of all the moving sights that we saw upon the screen to-night I think nothing surpassed the photograph of the rough cairn which was heaped by the loving hands of his old comrades in memory of their great leader. Since the time of the making of the road of loving hearts for the

funeral of Robert Louis Stevenson in Samoa, I do not think any tribute has been given by friends to a departed friend more touching or more magnificent than that cairn at Grytviken.

The PRESIDENT: You would hardly permit me to close this meeting without asking Mr. Rowett, the financier of the Expedition, to say a few words.

Mr. ROWETT: I thank you very much for the kind reception you have given me to-night. I can assure you it is a very great honour that my name should be associated with Sir Ernest Shackleton, that great Englishman, in this his last expedition. Commander Wild has told you the story of the *Quest*. It required a Shackleton to organize and equip this Expedition in the few months he had in which to do it, and it certainly required, after Shackleton died, a Wild to carry it out and bring the ship back safely. There is one man who hardly spoke to-night though he was called on first, and I cannot do less than pay him a very great tribute. He was the confidant of Shackleton and also of Commander Wild. Not only on the Expedition but since his return he has done his utmost to uphold the honour of the Expedition. I of course refer to Dr. Macklin. It would be invidious indeed of me to speak of the other members of the Expedition. They have all done their duty to the best of their ability. The last words which Shackleton wrote to me were: "Never for me the lowered banner; never the lost endeavour." In that spirit they carried on, and they have set an example which is worthy of the best traditions of British exploration and British endeavour.

The PRESIDENT: It now only remains for us to pass a very hearty vote of thanks to the lecturer this evening. Those amongst you who are scientific geographers will no doubt have appreciated the amount of solid scientific work which has been done. Those of you who cannot be described strictly as scientific geographers will probably go away with a vivid recollection of the sparkling sense of humour with which Commander Wild gave us his narrative, from his description of the deficiencies of the ship which saved the life of Commander Worsley to his mention of his vicarious generosity to the people at Tristan da Cunha. Probably the most vivid impression which those amongst you who are not good sailors will carry home with you to bed will be the disconcerting instability of the St. Paul Rocks, at any rate as displayed by the kinematograph. I need hardly formally put the vote of thanks on an occasion of this kind. I am sure you will show your appreciation of the lecture this evening in the usual hearty manner.

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## THE PROPOSED DETERMINATION OF PRIMARY LONGITUDES BY INTERNATIONAL CO-OPERATION

**Colonel Sir Gerald Lenox-Conyngham, F.R.S.**

*Read at the Afternoon Meeting of the Society*, 18 *December* 1922

THE subject for discussion this afternoon is a project for the determination of primary longitudes by international co-operation, brought forward at the meeting of the International Unions for Astronomy and Geodesy held in Rome last May, when a Joint Committee was formed to consider it. A scheme submitted to the Committee was, I believe, approved, at any rate in outline. When, however, this scheme

was seen by some of those in this country who are interested in the subject, it appeared open to a good deal of criticism from the geographical and geodetic point of view. It was therefore thought useful to bring the question up at one of the afternoon meetings of this Society, and I was invited to open the discussion.

The scheme was prepared in French, and I have made a rough though I hope not inaccurate translation of it; it runs as follows:—

## OUTLINE OF A PROJECT FOR THE ESTABLISHMENT OF A NEW FRAMEWORK OF GEOGRAPHICAL POSITIONS OF IMPORTANT POINTS ON THE EARTH'S SURFACE

**General Considerations.**—Hitherto determinations of the geographical positions of the principal points of the surface of the Earth, by observations of their astronomical coordinates, have been made without any connected plan and by various methods. It was found also, when the progress of science rendered it possible to make precise tests of the results obtained by the old operations, that there were discordances of an inadmissible magnitude. Thus, for instance, observations of differences of longitude made at the end of 1920 in Australia by means of radio-signals sent out by Lyons, seem to indicate the existence of an error of about one second of time in the values hitherto accepted for the longitudes of the Australian Observatories.

We have, moreover, no right to assert that this divergence is due to the imperfection of the older methods rather than to a possible deformation of the surface of the Earth.

It appears therefore necessary to establish a general plan for the operations of astronomical triangulation, of the greatest precision that is possible in the present state of science and technique.

These operations should aim first at a limited number of points, the positions of which will be determined by a special operation, which will be the basis of all further work, and from which extensions will be made to all important points on the earth's surface.

This principal operation will consist of determining the difference of longitude between the vertices, taken in order, of a closed polygon round the Earth, so that the precision of the observations may be deduced from the value of the closing error of the polygon, all systematic errors being supposed eliminated.

By means of secondary operations as many points as are desired can be connected to the vertices of the principal polygon.

Such operations may be carried out at the same time as the principal one, so as to profit by the observations and computations made on that occasion, or they may be made subsequently at any time.

In any case the secondary operations will be designed and executed so as to prevent them from affecting the principal operation in any way.

The vertices of the fundamental polygon will be placed in permanent observatories so that all methods and apparatus capable of giving the maximum of precision may be conveniently employed and also in order that it may be possible afterwards to keep a continuous watch on the values determined by the fundamental operation—by observing the daily time signals, for instance, and by making the best clocks of each observatory contribute—in order to see whether the longitudes undergo any variation in the course of time. If considered useful the fundamental operation could be repeated at some future date.

It would appear necessary to undertake, at the same time as the principal

operation, certain secondary operations of particular importance: namely, connections with the prime meridian of Greenwich, with the Observatory of Paris (*Bureau International de l'heure*), and also with a point situated at such a distance from the principal polygon that a subsequent comparison of the variation of its coordinates with the variations of the co-ordinates of the vertices of the polygon may aid in the study of the possible deformation of the crust of the Earth.

**Choice of the Principal Polygon.**—The number of the vertices of the principal polygon should clearly be kept as small as possible. On the other hand, it is of special importance that the astronomical observations at the two places, between which the difference of longitude is to be determined, should be made simultaneously; and that the clocks at these places should be compared at an epoch as little separated as possible from that at which the astronomical observations are made.

We may therefore decide on three as the number of the vertices of the polygon, for they will thus have a difference of longitude of 8 hours between them, and we may choose them in a mean latitude. During the winter, the length of the nights being then over 8 hours, it will be easy to make the simultaneous observations referred to above at two consecutive stations.

Two series of astronomical observations ought to be made at each station; one at the beginning of the night to serve for the determination of the difference of longitude with the next point to the east, the other at the end of the night for that with the next point to the west.

Similarly, the clock employed at a station should be compared twice each night, at the beginning of the night with the clock to the east, and at the end of the night with the clock to the west. This double comparison would not be necessary if it was only a question of avoiding the possible errors due to the rate of the clock, for we possess clocks whose rate is very regular. But it is indispensable in order to make the closure test legitimate. This test consists of taking the sum of the differences of longitude between each pair of stations and comparing this sum with 360° in order to determine the true error of closure.

Furthermore, in order to obtain the rate of the clocks independently of possible errors in the evaluation of the times of transmission due to the propagation of the waves, it will be suitable to make two comparisons each night at each station, one at the beginning and one at the end of the night by means of the signals emitted from the same radio-station.

There will thus be four comparisons to make each night at each station.

It will be advantageous to use as signals for the comparisons those emitted by three different radio-stations, situated for example between the vertices of the fundamental polygon.

When possible it will be interesting to compare the signals emitted by two or even by all three of the three radio-stations, with the clock at each of the three vertices of the polygon, for one will then be able to discover whether or not the speed of propagation of the Hertzian waves on the surface of the Earth is variable according to the direction of this propagation with reference to the rotation of the Earth.

The three vertices of the principal polygon should be nearly equi-distant and situated in about the same latitude so that the same zenith stars may be observed at each, and so that any errors in the right ascensions of the stars observed, and especially of the circumpolars, may have as little influence as possible on the measurement of the difference of longitude.

The observatories of Algiers, Shanghai, and one in the region of San Francisco seem to be the only ones which satisfy the desired conditions.

The three very powerful radio-stations of Bordeaux, Honolulu, and Annapolis will permit of the comparisons Algiers—Shanghai, Shanghai—San Francisco, San Francisco—Algiers being made. Bordeaux and Annapolis will be employed also for the connection of the principal polygon with Greenwich, Paris, and the distant point mentioned above, which might be chosen in New Zealand.

As for the secondary operations which certain nations might consider it useful to undertake at the same time as the principal operation was proceeding, such signals sent out by the three great radio-stations (Bordeaux, Honolulu, Annapolis) as would give a direct connection to the nearest station of the polygon would be made use of.

**Astronomical Operations.**—The determination of the latitudes of the three vertices does not present any special interest; it will, however, be useful to make it at the same time as the determinations of the differences of longitude, in order to possess contemporaneous measurements of the two co-ordinates of each of the points.

To determine the time it will evidently be suitable to use similar instruments at the three stations.

It must be noticed, however, that if the instruments that are used have unknown systematic errors the influence of these errors on the results will be eliminated from the sum of the differences of longitude between each pair of stations, and the precision of the results deduced from the error of closure of the polygon will not be correct.

It will therefore be necessary to employ simultaneously at each station of observation two instruments based on different principles and consequently not in danger of having the same systematic errors. If the results given by the two instruments are sensibly identical we shall have the best guarantee of their truth.

As primary instruments, meridian telescopes of moderate dimensions, but optically as powerful as possible, will be employed. They will be reversible and will be furnished with moving-wire micrometers worked by motors. These instruments will as far as possible be identical at the three stations. They will be tested simultaneously with the greatest care, especially as regards the levels, before they are sent out.

The observers who are to work with the meridian telescopes will meet before their departure and after their return, and their personal equations will be determined by simultaneous observations made with their respective instruments. If possible it will be preferable for each observer to determine his absolute personal equation every day during the operations, and in that case the exchange of observers will be unnecessary.

As the secondary instrument the prismatic astrolabe will be used—either the normal model or a photographic model if the latter has been successfully constructed. Its principle is entirely different from that of the meridian telescope, and it has already given excellent results in a great number of cases. The personal equation of the observers will be determined before and after the operations, or better each day during the observations by the Favé method, by means of an absolute personal equation apparatus.

After the completion of the principal operation it would be a great advantage to leave the instruments which had been used on it with the three observatories of Algiers, Shanghai, and San Francisco respectively, in order to allow the normal staff of these observatories to undertake a continuous study of the variations alluded to above.

Very special care will be used in the choice of the clocks and in their installation, particularly in all that concerns the precautions to be taken to protect them against the effects of variations of temperature. Two clocks at least would be used at each of the three vertices of the polygon.

The same applies to all that concerns the choice of the chronographs, the constants of which will be measured with the greatest precision and frequently verified.

As for the observatories themselves, a catalogue will be made of stars of which the positions are well known and comprising a sufficiently large number of circumpolars. The observing instrument would be furnished with means for reducing the brightness of the more brilliant stars.

The same observer will make the two series of observations at the beginning and the end of the night; the interval of about six hours between the two series will allow him to get some rest.

**Radio-Telegraph Signals.**—To obtain the maximum of precision the comparisons of the local clocks with the wireless signals will be made by registration on a special chronograph. Nevertheless in order not to risk the complete loss of good astronomical evenings when this registration is confused or out of order, the wireless signals will be so arranged as to allow of comparisons being made by ear as well. For this it will be sufficient to send series of "Scientific Signals" similar to those which were decided on by the "International Conference of the Time" (*Conférence Internationale de l'heure*) in 1912 (300 beats at intervals of one second less 1/50). The commencement of the last beat defines the instant of the comparison. It will thus be possible, if the occasion arises, to employ either the one or the other of the two methods of comparison, or to make a comparison by ear with almost the whole of the series of beats and thus determine the time of the beginning of the 300th, and also to register the end of the series with a view to getting a written record of the last beat, the time of which will thus be determined twice over.

The means of receiving the wireless signals should be as perfect as possible, and should be protected from perturbations of all kinds. The time-constants of all the wireless apparatus, including the registration device, will be determined with the maximum of precision.

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[*The remainder deals with questions of finance.*]

Such is the scheme. Now I will first say a word or two on what should, in my opinion, be the objects aimed at. For geography and geodesy we want to know the longitude of as many places as possible. We want, first of all perhaps, to know the longitudes of the stations of origin of all systems of triangulation, so that when two systems meet we shall know that such discrepancies as are revealed are not merely due to discordances between their initial longitudes. Then all observatories where astronomical work is being done should know their longitudes with accuracy; and thirdly, within the area covered by a single system of triangulation, it is very advantageous to be able to determine the longitudes of numerous points, both on account of the valuable safeguard which they afford against the accumulation of angular error, and also on account of the light they throw on the question of local attraction. Lastly, it will no

doubt be desirable for every seaport to have its longitude fixed with reasonable accuracy.

The precision required for these different kinds of places will be different, but it is important that the longitudes should all be in the same terms, and clearly they should all be longitudes from Greenwich. Hence the first desideratum is to make the connection with Greenwich as direct as possible. The scheme, however, takes as its primary object the accurate determination of the differences of longitude between the three places named and puts the connection with Greenwich in the second place. This seems to me wrong. I dare say that if the scheme were carried out this secondary operation would be quite satisfactorily done, and that the fact of its having been given a subordinate position would not have any evil effect; but in the outline of the scheme I think the importance of expressing all longitudes in terms of Greenwich should have been more clearly emphasized.

Supposing, however, that the operations called primary and secondary in the scheme have been successfully performed, and that in consequence we know the longitudes of Algiers, Shanghai, and San Francisco with great accuracy, does this assist us at all? The scheme says that by means of secondary operations as many points as are desired can be connected with the vertices of the principal polygon, which means, I take it, that further differential operations between these three places and other points of importance in their several regions would be undertaken; then between these points and a larger number of less important ones; and so on.

In the days before wireless telegraphy arcs of longitude were determined by the interchange of signals through telegraph wires or cables, and for practical reasons it was generally necessary, if the arc to be measured was of considerable length, to divide it up into a number of parts, to measure each part and then add the results together. An example will make the matter clearer. When the longitude of India was redetermined in 1895 it was found necessary to divide the whole arc into four parts, namely, Greenwich to Potsdam, Potsdam to Tehran in Persia, Tehran to Bushire on the Persian Gulf, and Bushire to Karachi. The connection of Karachi with Kalianpur, the station of origin of the Indian Triangulation, had been made previously.

If by international co-operation the longitude of Tehran (for instance) had been determined, then of the links which I have mentioned two would have been eliminated and the operation reduced to half its dimensions. And if conditions were the same now as they were then, the measurement of a number of primary arcs of longitude by International Co-operation would be a useful work. But wireless telegraphy has completely altered the problems of longitude determination; we are no longer concerned with the routes followed by cables and land lines, and the distance to which signals can be sent in one direct operation is very much greater than formerly.

If it were desired to make a determination of the longitude of India to-day what would be the procedure? The observer would be equipped with a transit instrument, a chronometer, a chronograph, and a wireless receiving set. He would take these to Kalianpur, and placing his transit instrument over the triangulation mark would determine his local time; then he would turn to his wireless set and would pick up the time signals sent out from the Eiffel Tower, which gives Greenwich time, and so would find the difference between local time and Greenwich time, which is the longitude of his transit instrument. The precision of the result would depend on the elaboration of the equipment with which he had been provided and on the amount of time that he could devote to the work; that is to say, if the accuracy of the Eiffel Tower signals can be relied on.

I have named the Eiffel Tower signals because I believe that at present they are the most accurately controlled and carefully watched, and every day very shortly after the time signals have been sent out a message is transmitted, stating the provisional error of the signal to the nearest hundredth of a second, while eventually a list of the definitive errors is published.

If the signals from the Eiffel Tower could be picked up with ease and certainty at all points of the Earth's surface, then this one set of signals would suffice for all longitude operations, but if not, then it will be necessary to arrange for the emission of time signals from other wireless stations. The number of such stations would not be large. If, for instance, a distance of 90° of great circle was not thought too great—and I know that the Eiffel Tower signals have been received in India, which is about that distance away—then two emission stations, say the Eiffel Tower and some place in its antipodes, perhaps Dunedin in New Zealand, would suffice for the whole world. If only 60° of great circle were admissible, then besides these two we should require three more stations situated on the great circle of which the Eiffel Tower is the pole—and so on.

My idea, then, of the way in which international co-operation should be called in to aid in the determination of longitudes is that suitable emission stations should be selected and plans adopted for the continuous and accurate determination, day by day, of the errors of the time signals that are sent out. This is now being done for the Eiffel Tower signals by the Paris Observatory, and similar measures would suffice for the other stations selected. There is one necessary preliminary, however, and that is the accurate determination of the Greenwich longitude of the observatory or observatories which undertake the supervision of the time signals of the several emitting stations, so that they may be able to deduce Greenwich time from their own astronomical observations. For this purpose it is possible that a few fundamental longitude determinations such as those described in the scheme should be made. But

the choice of the stations would be guided by different ideas. The wireless stations should first be chosen, and then the observatories which are most conveniently situated with regard to them.

I now turn to another point. You will have noticed that in the scheme which I read to you considerable stress is laid on the advantage of being able to determine the closing error of the polygon if the latter encircles the Earth, so that the sum of the differences of longitude is 360°. The wording of the scheme seems to imply that this cannot be done unless the chain of stations encircles the earth, but the closing error test can be applied to the differences of longitude between any three stations, and in order to test the accuracy of the results in this way it is quite unnecessary to place the stations eight hours apart.

If the object is to investigate the laws of propagation of radio-signals then I dare say this spacing would be advantageous, but I don't think such an investigation should be the ruling consideration in a scheme for the determination of differences of longitude.

My view, however, is that the plan of determining *differences* of longitude, which was at one time the only practicable one, should be discontinued, or, to be more precise, that all determinations should be direct differences from Greenwich.

The longitude question has now become very like that of the latitude. Greenwich time sent out regularly by wireless all over the world gives the prime meridian a status almost equal to that of a naturally defined line such as the axis of the Earth's rotation ; and just as in latitude work each latitude is an independent quantity, standing by itself, so hence-forward each longitude should be independent.

It may be thought that in thus giving up the idea of determining differences and applying the test of the closing error, a safeguard is being lost ; but this is not really so. We are on much firmer ground when each determination stands by itself and its errors are not made up of two sets of errors entangled with one another.

The suggestion in the scheme that two independent instruments should be used for determining the time is good, and if the two are capable of giving results of equal precision then it is a valuable idea.

I have, unfortunately, no practical knowledge of the prismatic astrolabe, and it is futile to criticize on *à priori* grounds a method which has been found successful in practice. I will venture to say, however, chiefly in the hope of getting the opinions of others, that it seems to me improbable that the precision of the astrolabe result can be equal to that obtained with a suitable transit instrument.

In the astrolabe the direct and reflected images of the star approach and pass each other, and the observation consists of noting the instant of their coincidence. This is very similar to observing the passage of a star's image across a line, as in the transit. But in the transit there will be a set of ten lines or wires, and the mean of the ten observed times will

be, to a great extent, free from accidental error. In the astrolabe there will only be a single observation.

Furthermore, although the transit observation is freed from accidental error by having a number of wires in the field of view, yet it is found that the observation is subject to large systematic error due to the personal equation of the observer, and this was a source of serious uncertainty in the older longitude operations, in spite of precautions such as interchange of observers and careful measurements of their relative personal equation. But the greater part of this uncertainty—almost the whole, indeed—was removed by the invention of the moving-wire micrometer in which, instead of the instants of the passage of the star over fixed wires being noted by the observer, a movable wire is caused by the observer to keep in coincidence with the star as it traverses the field of view, the times of the passage of the wire over certain fixed points being automatically recorded by an electrical device.

It is perhaps not impossible that a plan of the same sort might be invented for the observation of the approach of the two images of the star in the prismatic astrolabe, but this has not yet been done, and for the present it appears to me that astrolabe observations will be subject to personal error similar in character and amount to that which affected transit observations before the introduction of the moving wire micrometer, with the added disadvantage that its amount will be even more difficult to determine.

As I have already said, however, I have but little knowledge of the astrolabe, and only wish to point out that caution should be used in accepting it as an instrument capable of giving confirmation to the results obtained with a transit when a high degree of precision is required.

I am afraid that almost all that I have said has been of a negative kind, so I will end on a positive note by repeating that in my opinion the best way in which the determination of longitudes can be assisted by international co-operation is by the selection of wireless stations for the emission of time signals in such number and in such positions as to provide the whole surface of the Earth with satisfactory means of finding Greenwich time, and by organizing the observation of the signals so that their errors may be determined and transmitted with accuracy and promptitude.

Before the paper the PRESIDENT (the EARL OF RONALDSHAY) said: The paper that we are to have this afternoon from Sir Gerald Lenox-Conyngham is upon a project for international cooperation in fixing primary longitudes. I do not pretend that this is a subject of which I have any particular knowledge myself. I do not propose, therefore, to stand between you and the lecturer.

*Colonel Sir Gerald Lenox-Conyngham then read the paper printed above, and a discussion followed.*

Sir FRANK DYSON (Astronomer Royal): I have been very interested in Colonel Sir Gerald Lenox-Conyngham's paper, and I was glad that he read

a short translation of the proposed international scheme, because with him I think that we should set to work in rather a different way. Of course wireless is a very great convenience to longitude determinations in the field, as there is no need for telegraphic connection, and, again, it improves the longitude determinations by there being no need for intermediary points. But the essential difficulty in longitude determinations is not the telegraphic transmission or the wireless transmission: it is the actual astronomical determination of time that is less accurate than the precision with which the signal can be sent, whether by cable or by wireless. It seems to me that the proper method to adopt with the facility which the wireless has given us is to utilize it as far as possible, and first of all in the principal observatories at Greenwich, Paris, Potsdam, and Washington. Each day the signals should be observed. For instance, at Greenwich we observe regularly the signals sent out from the Eiffel Tower, from Bordeaux (a high-power station which reaches South Africa and Australia quite easily), from Annapolis (the station near Washington, which can be received quite well in Europe and which can also be received in South Africa and Australia), and from the German station. If these are received by the various observatories we obtain each day, without more trouble, determinations of longitude.

For example, on the slide I have had thrown on the screen you have a record of observations made in September and October at Greenwich of the signal sent out by Annapolis. I should add that these signals were not received by ear, but were actually registered automatically. By correspondence with Washington we have obtained the corrections to the times of the signals given by the observations of that observatory. Thus for each of these days we have a determination of the longitude of Washington. It gave no trouble to anybody; it simply came in the ordinary course of the day's work. There was no expedition wanted; no observatory to be set up. That process can, and I think should, be carried out by all the principal observatories who make the determinations. In that way the longitudes of the principal stations can be gradually improved. They will not be improved by a short series, but this sort of thing can go on for years and the longitudes will be known with greater accuracy.

Supposing anybody else at any station wishes to get a determination of his longitude, he would observe wireless signals. For instance, the Cape might receive the signals from Annapolis. Comparing their times with those observed at Greenwich a direct comparison with Greenwich is obtained for each day. Or they might write to Paris and say, "What do you make it?" and so they get a direct comparison with Paris, and applying the difference Paris–Greenwich they get a second determination which could be combined with the determination made directly with Greenwich. That seems to me the right way to go about this question of improving longitudes: to start with what we have, to utilize these wireless signals by observing them constantly and regularly and as accurately as possible and publishing the results. Then it is only necessary to take the difference between the published figures to get the longitudes of Greenwich–Paris, Greenwich–Washington, Greenwich–Potsdam, or whatever the place might be.

I think, as Sir Gerald Lenox-Conyngham said, the problem of determining longitudes has been simplified not only by this but by the invention of the moving wire micrometer. There is no doubt that personal equations are so largely eliminated there that, except in cases of very high precision, it is unnecessary to interchange observers. The observer's personal equation is extremely small.

Then the point comes up: What was the idea underlying this suggestion of

three stations in Algiers, Shanghai, and San Francisco? There is already an observatory at Algiers. I do not think there is one at San Francisco, although there is the Lick Observatory not far away. I do not think there is one at Shanghai except a small one. I think the idea in the minds of the authors of this scheme was this: that there might be a variation in the longitudes. The French and the Americans determined the longitudes of Paris and Washington twice, in two parts of the same operation, not long ago, and, curiously enough, the French and Americans agreed in both the first and second part, but differed by a very considerable quantity between their two determinations. Possibly the authors of the scheme may have had the impression that was due to a variation of longitude. Such a variation does not seem to me at all credible. I think the differences were in some way due to instrumental causes. Of course I am not denying the possibility of slight changes in longitude, but if one considers how big the variation in latitude is—the total range is about 0·5 of a second of arc, equivalent, let us say, to 0·05 of a second of time in these latitudes—well, you want very good observing to be sure of differences whose range is of that order.

Again, if stations were set up at Algiers, Shanghai, and San Francisco, would they be permanent stations? If they were not permanent stations they would certainly be no good for secondary determinations of longitudes, because you could only make a determination of longitude thom them if they were observing on the same dates on which you were observing, so that an expedition, which I think was the first suggestion, to determine these three longitudes would be of no value at all for further longitude determinations. But, as Sir Gerald Lenox-Conyngham says, there is, I think, not much difficulty in getting direct connections or very close connections with Greenwich. Certainly some Australian longitudes were recently made by listening to the Lyons signals. We received the signals of Lyons at Greenwich and forwarded the difference to the astronomer in Australia, and he got his longitude directly with Greenwich. He also got comparison from Paris and applied the longitude of Greenwich–Paris, and so got a second determination. He did the same with Washington and, I think, Ottawa. There we have an example of the way longitudes can and are being determined at present.

The scheme which we have heard outlined seems to me to be formulating a new scheme, logical but not entirely practical, rather than developing the existing methods; my own feeling is that we shall do better if observatories which are in the habit of making accurate time determinations will observe wireless signals with the greatest accuracy they can, and constantly and regularly compare their results.

Colonel Sir CHARLES CLOSE: I agree entirely with what Sir Gerald Lenox-Conyngham has said, and I was most interested in what the Astronomer Royal has described as the kind of work which is being done at Greenwich for the determination of longitude. It seems to me that if everything which General Ferrié proposes was actually carried out we should not be better off than now. In particular, his reduction of stations to three does not seem a very happy suggestion; we want stations all over the world. His three stations are not very conveniently situated; they do not connect the great triangulations. Algiers is not very well connected with Europe; Shanghai is not connected at all with India, and so on. Then it seems to me that this is an example of the danger of rushing international co-operation. Here you find a scheme got out by one or two men; not thoroughly debated; presented, I believe, at the Rome Meeting of the International Union for Geophysics and Geodesy.

It is clear, in a conference of that kind, there is not the time to examine adequately all of the many questions that are before you. If international co-operation is to be any good we must try and avoid this sort of imperfect collaboration. Here we have a scheme suddenly rushed through, presented, I fancy, with the authority of the Union. It is clear, however, it has not in reality the full authority of the Union because the higher English authorities are against it; the Astronomer Royal does not approve of it.

What is the situation now? Supposing that the scheme is the present official scheme, is it going to be carried out and a lot of money spent on it with no satisfactory result? I think we ought at this meeting, if possible, to find some means of expressing the opinion of the Royal Geographical Society on the scheme with a view to getting a resolution passed through the proper channels, so as to obtain a reconsideration of the problem. I believe that is the first thing we ought to do, to have the whole matter properly reconsidered. Let a real International Committee assemble, if necessary, and let those who have every reason to express an opinion on the subject get together and formulate a scheme that will be accepted, and do not let this country accept a half-baked scheme which we do not view with favour, and which, as we have heard, is not likely to produce satisfactory results.

Before I sit down I should like to thank Sir Gerald Lenox-Conyngham for the very clear way in which he has put the whole matter before us.

The PRESIDENT: Arising out of what Sir Charles Close has said, would he like to move a resolution at this meeting? He suggested that the views of the Royal Geographical Society, which would have to mean the views of this meeting, should be forwarded to the proper quarters. Certainly the most satisfactory way of doing that would be, I think, to pass a resolution. Perhaps Sir Charles Close might, while I call on other speakers, be turning over in his mind the terms of some resolution he would like to put to the meeting.

Admiral F. C. LEARMONTH (Hydrographer of the Navy): We have all listened with great interest to the previous speakers, who have covered nearly all the ground, on which there is very little further to be said. On the Prismatic Astrolabe I should like to make one or two remarks. We are using these instruments in the Naval Service, but I am by no means clear at the present time that it is considered an instrument of precision, though I am aware that it has been used in the Egyptian Government Survey. I thoroughly associate myself with what Sir Gerald Lenox-Conyngham has said about its imperfections —if I may so call them. In order to admit of a wider range of observation an instrument is being constructed at the National Physical Laboratory, embodying these and other improvements suggested by its use, and to overcome some of the difficulties met with in the field, one of the principal alterations introduced being, that the faces of the prism are cut at slightly different angles carefully determined, thus admitting by rotation an opportunity for a renewed observation from each face.

With regard to the more exact determination of the present accepted longitudes and the resulting effect upon the users of Admiralty charts, any such final determination and acceptance would be very welcome, but at the present time the longitude of the Admiralty charts is of necessity in many cases slightly in error from various causes dating back into the past, and to attempt to bring them all into line and in general agreement would be a very great labour involving a considerable period of time; but, speaking generally, there only remain to be reconciled the smaller errors of precision now being discussed, a satisfactory agreement upon which would certainly be welcomed by seamen.

As a good instance of the uncertainty yet prevailing, that of the longitude of Madras may be taken as one, upon which most of the hydrographic survey work in Australia and the East is dependent; and there are other cases where it is necessary to use some point of origin, the longitude of which has not been satisfactorily determined. I quite agree with what Sir Gerald Lenox-Conyngham has said in his lecture, and also with the remarks of the Astronomer Royal, who has shown so clearly what has been done almost daily by Astronomers, though perhaps known only to a few. I also entirely agree with what Sir Charles Close has said, and particularly as to the desirability of endeavouring to approach the proper quarter in the manner most suitable, though I am not quite clear how best that can be done; but I suggest a start be made if the Chairman sees his way to adopt any recommendation made before this meeting dissolves. It would undoubtedly carry weight, and this meeting would not be nugatory as might otherwise be the case. It would appear that insufficient consideration was given at the assembly in Rome last summer, and it certainly appears evident from the remarks of the lecturer that the proper steps are not being taken to achieve the result aimed at.

With regard to the Astronomer Royal's remarks about Shanghai I quite agree, so far as my information goes, that it has not changed its status from a very minor observatory since I last visited it some years ago. I do not think there is anything else that I can usefully add, beyond strongly associating myself with what Sir Charles Close has said, and consider it would be well if an accepted recommendation, as a result of this meeting, could be forwarded on the lines that he suggests.

Colonel WINTERBOTHAM: I have nothing to add on the international aspect of this affair, but, speaking nationally, if there is any money to spend we should like wireless emitting stations so generously spaced over the Empire that no explorer should find it difficult to make a direct determination of longitude with quite a small receiving set. I think Sir Gerald Lenox-Conyngham possibly talked of rather larger arcs than the normal surveyor with a small receiving set would be capable of working to. One knows that there is a good deal of difficulty in picking up wireless signals in the heart of Africa because of "atmospherics," and one knows, too, that expeditions in little-known parts will not be able to carry large receiving sets. So I think that from a national point of view we should have a sufficient number of wireless emitting stations in Africa, Asia, and Australia to enable such determinations to be made. I suppose the time will come when an aeroplane will land to determine its latitude and longitude in order to help to place its air-photo-topography in position.

Mr. JOLLY (Ordnance Survey): There is one aspect of the operation which has perhaps not been sufficiently looked at; that is, you can regard it not only as something to help you to determine longitudes very accurately for various reasons, but also regard it as an operation which is to be repeated precisely in the same way from epoch to epoch, in order to determine whether there are any movements in the outer layers of the Earth. It seems to me that those two objects are very distinct from one another, and, if the scheme has anything useful in it at all, it is in this latter conception of it. In that connection the origin is of no importance whatever. You simply want to tell whether movements in the sense of changes of longitude have taken place. But it would be desirable to add one or two more stations in the other hemisphere and to determine the various differences of longitude entirely independently of one another. In the scheme I see no usefulness—assuming it is to be done in the way put forward—in determining your eastward longitude at the beginning of

the same night at the end of which you determine your westward longitude. It seems to me making too hard work of it. It makes the arrangements more liable to break down and, if anything, it makes the eastward and westward longitude determinations a little less independent the one of the other than they would otherwise be. If you had more stations in the other hemisphere you could determine the other arcs of longitude independently of one another and so get, in the real sense of the word, a network, with the accompanying benefit of the adjustment of the observations.

Mr. G. T. McCaw (War Office): There are only two points to which I should like to make some reference. I think Sir Gerald Lenox-Conyngham has put the question before us very clearly, and the Astronomer Royal has almost, perhaps, settled the question so far as this country is concerned. It appeared to me, listening to what has been said, that one objection to this scheme would be that we could never regard these three stations as providing fundamental longitudes. If they were ever likely to become fundamental longitudes, something more could be said on their behalf. But these stations will always be affected by errors, and I do not see how any of them, in view of unknown local attraction as an example merely of one source of error, could be considered as in any sense fundamental. In modern practice it is usual to adjust a whole series of longitudes and get rid of the outstanding errors by the well-known method of least squares; that method, however, cannot be applied with any success to a small number of stations such as the three proposed.

With regard to the other point, to which Mr. Jolly has already referred, I was struck in reading a popular epitome of the proposals by the fact that the authors naturally consider that the supposed movement of the Earth's crust is an important subject for investigation, and that their scheme was in a measure dictated by a desire to determine whether the oversliding movement, with which the name of Wegener is associated at the moment, is actually a reality. But I think the Astronomer Royal has made it quite clear that the investigations which he is making daily and which are being made in the other observatories of the world will be equally valuable for determining the movement of the Earth's crust if such a thing exists—more valuable, in fact, because observatories are numerous and permanent, the observations may be conducted continuously, the equipment and personnel are naturally superior, and the work is done without additional expenditure.

Mr. Hinks: I take it that one of the advantages of the three stations at eight-hour intervals, mentioned by Sir Gerald Lenox-Conyngham, was that it would be possible so to arrange the determination—if it were done in the winter—as to eliminate star places altogether. I should like to ask the Astronomer Royal whether, in his opinion, that is of real importance. It is really a question of whether, if you work with star places at random, you do in the end get better results than if you confine yourself to three observatories working with the same selected stars. It depends on your judgment of the accuracy of the present fundamental star systems.

Sir Frank Dyson: If one were determining longitudes between two places in nearly the same latitude I take it, if they were not too far apart, one would try to use the same stars as far as possible. But for these three stations one might very well use stars not very far from the equator whose positions should not have accidental errors of more than a fiftieth of a second; about 0·02 or 0·03 second at most. I should have thought that so long as they agreed to a definite system of star places there was very little risk of introducing anything serious. But it seems to me that if two fixed observatories carry on their

observations for a whole year anything of that sort will almost automatically go out, because they all in the course of the year have used the same stars and the differences will practically be eliminated.

Dr. EVANS: With regard to Colonel Winterbotham's remark on the necessity of large stations for sending out signals, I may remind him that during the war we had a large number of stations scattered about the world. For instance, there was one in Jamaica. A good many of those stations have been discontinued, so that the question is not so much one of establishing signal stations but merely restoring those which were in use during the war. I think what we have heard to-night is sufficient to convince us that the present system which is carried out by the great observatories of the world answers every purpose which is proposed by the scheme of the Geodetic Union. But it is important, however, to bear in mind the desirability of determining as accurately as possible the longitudes of outlying places such as South Georgia and the Falkland Islands. Would it be possible to establish temporary observatories in those places to determine the longitudes, not with the exactness with which we can determine them at the great observatories, but with such accuracy that in the course of say fifty years those who come after us could be satisfied whether there is or is not any definite change of longitude? I should like to ask the Hydrographer of the Admiralty whether he thinks it would come within the scope of the work of the Navy to make such observations. They have a number of officers fully qualified to set up such temporary observatories. By obtaining trustworthy determinations of the positions at the present time of a number of localities throughout the world we shall earn the gratitude of future investigators of the Earth's crust.

Admiral LEARMONTH: Might I reply to that suggestion of re-establishing the wireless telegraph stations mentioned, such as the Falkland Islands and a good many others. At the present time a large number of these, erected by the Admiralty during the war period, have been dismantled or closed, such as St. Helena, Falkland Islands, and others within the British Empire. There would be no great difficulty except, first of all, that of expense in re-establishing the stations themselves; in some cases the instruments having been removed and in others not. To carry out the purpose suggested would offer no great difficulty, and the actual observations themselves could be better undertaken by astronomers than by naval officers, the number of whom trained in the precise use of fixed instruments for astronomical observations is very small. To obtain satisfactory results it would be necessary to spread the observations over a considerable period, this apart from the delays of weather, etc., and I am afraid the Navy would not be able to undertake the series of enterprises which would be necessary; but, as I previously stated, the main difficulty is that of providing sufficient funds for any work of this nature.

Colonel Sir GERALD LENOX-CONYNGHAM: I am afraid I ignored the point of a watch being kept on longitudes to see whether any variations take place in the course of time. That was mentioned in the scheme, and I should have referred to it. Mr. Jolly's remark has reminded me of it. But I think the matter really is provided for in what the Astronomer Royal has told us is being done, namely, the constant timing of signals so that the longitude of a number of places is being watched. Also if one of the objects in view is to see whether there is any truth in Wegener's theories of "waltzing continents," as I think they have been called, I do not consider the three places mentioned—Algiers, Shanghai, and San Francisco—are at all happily chosen. We should look for those places which are under suspicion of having moved and put our observa-

tories there. So that I am afraid on these grounds, too, I find that the scheme lacks merit.

The PRESIDENT: It is quite clear, I think, that Sir Gerald Lenox-Conyngham has raised a question of very considerable importance, and it is equally clear that there is a consensus of opinion amongst British experts—at any rate, that opinion has been unanimous this afternoon—that the proposal which has been put forward by the French, largely I believe by the suggestion of General Ferrié, is perhaps somewhat premature and not necessarily well calculated to achieve the objects for which it is designed. In those circumstances I think it would be useful if a record of the opinion which has been expressed this afternoon was made, and Sir Charles Close, following up my suggestion, has drafted a resolution in these terms: "That whilst appreciating fully the work done by the French astronomers and physicists in developing the determination of wireless longitudes, this meeting of the Royal Geographical Society"—and I would like to suggest an alteration of the wording there; I would prefer to say, "this meeting of members of the Royal Geographical Society," because we could hardly pledge the Society without submitting the resolution to the Council—"this meeting of members of the Royal Geographical Society is of opinion that the scheme outlined by General Ferrié requires reconsideration in the directions indicated by the speakers." If this Meeting passes a resolution of that kind it might, as Sir Charles Close suggests, be forwarded to the Royal Society with a request that they should bring it, in the first instance, to the notice of the National Committee for Geodesy and Geophysics. With a view to making quite clear to the Royal Society the character of the meeting I would suggest that it might be forwarded with a covering letter explaining the nature of the meeting at which the resolution was passed, and, if the speakers raise no objection, giving a list of those who took part in the discussion. I make that suggestion because I think it would prevent any possibility of misunderstanding in the future in case the resolution was quoted as being a resolution of the Royal Geographical Society. If Sir Charles Close will be prepared to accept my suggestion for the small alteration, I shall be very glad if he will formally move the resolution and some one kindly second it.

Sir CHARLES CLOSE: I willingly accept the small alteration, and I beg formally to move the resolution which the President has just read.

Major-General Lord EDWARD GLEICHEN formally seconded the motion. The account of the proceedings of the meeting would be sent with the resolution.

The PRESIDENT then put the motion to the meeting, and it was carried as follows:—

> "That whilst appreciating fully the work done by the French astronomers and physicists in developing the determination of wireless longitudes, this meeting of members of the Royal Geographical Society is of opinion that the scheme outlined by General Ferrié requires reconsideration in the directions indicated by the speakers."

The PRESIDENT: I have nothing further to add except to express, on my own behalf once more, and on behalf of this meeting, our great appreciation of the paper which Sir Gerald Lenox-Conyngham has given to us this afternoon. We are most grateful to him for the trouble he has taken in putting this matter so clearly before us.

## BRIGADIER-GENERAL GEORGE PEREIRA'S JOURNEY TO LHASA

*By the kindness of Major-General Sir Cecil Pereira we are allowed to publish the following account of his brother's remarkable journey from China to Lhasa and thence to India, extracted from letters received in the last few months.*—ED. *G. J.*

GENERAL GEORGE PEREIRA left Tangar on 11 May 1922 with eight horses and twenty mules, his boy, six men, and four soldiers. He travelled up the Sining valley, seeing a few Chinese villages, passed Shara Kuto 27 miles from Tangar, and shortly afterwards crossed the Jih-yueh range, the geographical boundary between China and Tibet, though the present political boundary is the Tang-la range running east and west south-west of Jyekundo. In this area he met Chinese, Tibetans, and mounted Mongols. The altitude was about 11,000 feet. With the exception of lamas all the inhabitants are nomads who tend their flocks, and there are small patches of cultivation. The country consists of grass plains traversed by mountain ranges. Hares, marmot, chicoe, and lizards were seen. Sheep, chickens, and eggs could be bought. At distances varying from 12 to 20 miles to the north ran the Koko range south of the lake of the same name.

Gunga Nor was reached on May 15, and in the surrounding plain there were herds of horses and cattle apparently untended, though occasional Tibetan tents were seen. The route continued across the same plain, scrub and grass covered, and watered by two streams. General Pereira had gone ahead of his caravan and spent a chilly and foodless night in the open owing to the caravan losing its way, and he did not find them until the following morning. On May 19 he crossed the Hu-ka-ya-hu Pass, 12,000 feet, and then descended to the Ta-ho, where he found a Chinese company of sixty to seventy Mohammedan soldiers. In this valley he saw the first trees since leaving the Sining valley.

Two days later there was a heavy snowstorm and his mules broke down, unable to stand the severe climate with very poor grazing at times, and he was compelled to return to Ta-ho-pa to hire extra transport and an escort, as Golok raiding parties were reported in the neighbourhood. Though the military use mule transport, as their mules are fit and they travel with light loads rapidly across areas where the grazing is poor, on the journey mules were not found satisfactory and were the cause of constant delays. Yaks are slow but sure.

The big Cha-su-ra Pass (14,607 feet) was crossed on May 25. There was snow on the plain beyond, and in the evening a strong west wind. The following day a view was obtained of the Amn'e Machin peak in the far distance to the south-east; it was seen from an altitude of 13,000

feet, and it must be well over 25,000 feet as it towers above everything around. On May 28 he passed Tong-ri-tsonak (lake) (on maps shown as Tos-sun Nor), and he camped near a big company of Tibetans with six hundred yaks. These were the first inhabitants he had seen since leaving Ta-ho-pa; they were very friendly. As these Tibetans were bound for Jyekundo he travelled the next stage with them.

On June 2 he reached the Hwang-ho (Yellow River), and forded it where it was 2 to 2½ feet deep and 30 yards wide. From here on there were many Tibetan camps with yaks and sheep and good grazing until Ch'a-la-tu camp, 14,802 feet, was reached on June 9.

The following day he crossed the Ch'a-la-ping plateau, over 15,000 feet, and on June 12 the Ya-kou Pass (15,439 feet), the highest point on the route; shortly afterwards the Ch'a-ho, the headwaters of the great Yalung River, was crossed. He reached Chu-chieh monastery (in Tibetan Ju-chieh Gomba) on June 17, nearly 450 miles from Tangar. The monastery contains about a hundred lamas of the Red sect. With the exception of mud barracks at Ta-ho-pa and Ch'a-pu-ch'a and the small villages near it, this was the first building seen since entering Tibet.

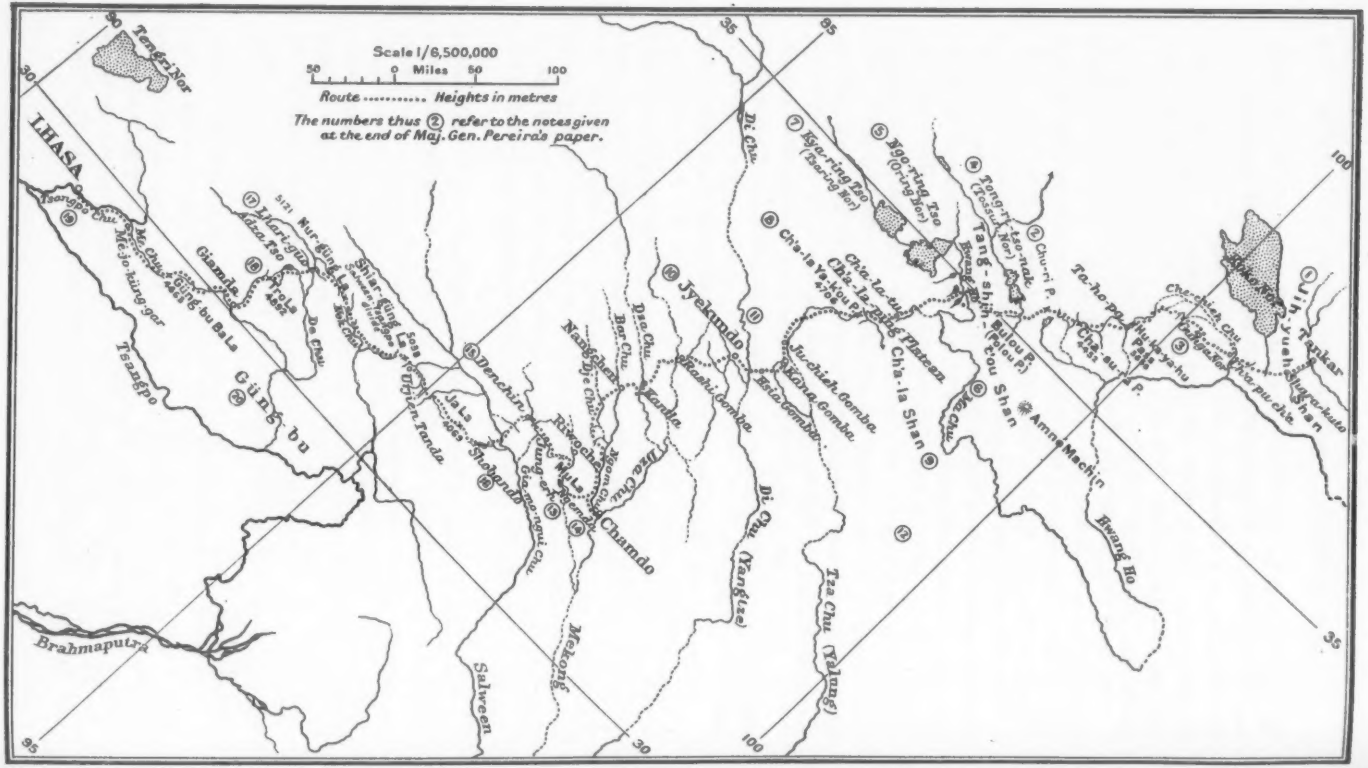
On June 18 he camped at Kana Monastery (two hundred lamas), and on June 20 at Hsiu Gomba, reaching Jyekundo on June 23, 518 miles from Tangar.

Before leaving Jyekundo on July 10 he sold nearly all his mules and horses and hired twenty-three "ula" yaks.

The first day's journey crossed the Ba-tang plateau (13,798 feet), after a climb of nearly 2000 feet. There were continuous climbs and descents into valleys with Tibetan camps, good grazing, and many flowers. He crossed the Sing-nak-ri-ya ridge, which rises to a height of 15,724 feet and is the divide between the Yang-tse and Mekong rivers. The country was practically devoid of trees. Rats (ara), marmots, hares, and gazelle were seen.

The general trend of the country in this part made the route a succession of precipitous climbs and descents over rocky tracks and occasionally across marshy places; then it led through beautiful grassy valleys with good grazing and many flowers. There were occasional Tibetan camps with flocks taking advantage of the good grazing; some downpours of rain and at times high winds that threatened to blow away the tents. To add to the discomforts, loads occasionally fell off the yaks when they were fording streams, with the result of wet clothing and blankets.

On July 12 he passed Rashi Gomba, a monastery of a thousand monks with a fine gold roof in the centre of the temple. The following day he crossed the valley of the Lung Chu (Wind River) and traversed some fir and bush tracts, the first tree region he had seen in Tibet excepting the Ta-ho-pu valley. He passed a Chinese caravan of twenty mules that had left Lhasa forty-five days previously. The Dze Chu (east


Scale 1/6,500,000
50 0 Miles 50 100
Route ..... Heights in metres
The numbers thus (2) refer to the notes given at the end of Maj. Gen. Pereira's paper.
LHASA
Tengri Nor
Tsangpo
Brahmaputra
Güng bu
Chamdo
Salween
Mekong
Di Chu (Yangtze)
Tza Chu (Yalung)
Hwang Ho
Amne Machin
Tankar
Kuku Nor
Tsaidam
Jyekundo
Ch'a-la Shan
Tang-shih Ho
Gulou R.
Gulou Shan
Ta-ho Pa
Denchin
Shobando
Kanda
Ch'a-la-tung Plateau
Ch'a-la-tung Pass
Ch'a-la Yakhou Pass
Ju-chieh Gomba
Kanua Gomba
Bero Gomba
Kyaring Tso (Tsaring Nor)
Ngo-ring Tso (Oring Nor)
Tong-ri tso nak (Dressul Nor)
Chu-ri P.
Ch'a-ma Pass
Ch'a-ma Chu
Hu-ya-hu Pass
Hu-ya-hu
Ch'a-ma Ch'a-ma
Ch'a-ma Chu
Ch'a-ma Pass
Ch'a-ma Chu
Yuen-hwang-kuo Shan
Ch'a-ma pu-chi
Ch'a-ma Chu
Ch'a-ma Pass
Ch'a-ma Chu
Ch'a-ma Pass
Ch'a-ma Chu
Ch'a-ma Pass

branch of the Mekong) was 80 yards wide with a very strong current, and is crossed in a coracle managed by a single paddle; transport animals have to swim.

The "ula," the system of hiring yak transport by the stage, was found to be extremely well organized and a great improvement on buying mules and ponies for the journey. Tibetan villages, like Chinese, are run by a headman who is responsible for the provision of "ula."

Kanda was reached on July 15. It is a small village on the Mekong. or Dza Chu. Teichman's route had been followed so far (see *Geogr. Journal* map, January 1922). Kozloff's, Rockhill's, and Bower's routes were all crossed further ahead.

The Mekong (Dza Chu), passed on the 16th, was 200 yards wide; there was only one coracle available and the animals swam, the yaks being encouraged by being pelted with stones. These river crossings were always lengthy proceedings.

The China–Tibet frontier was crossed on July 22 before reaching Tang-kwa, the route leaving the Tibetan kingdom of Nang-chen, which is under Chinese rule, and entering territory governed from Chamdo.

At this period there was constant rain; the route was constantly up and down stony hills, with many streams to be crossed and hardly ever a bridge. The villages are extremely small, two to seven houses, the houses built of mud and wattle, with plank floors and log roofs which very often leak. The windows occasionally have wooden shutters or merely a wooden framework, but without paper coverings as the Chinese have. Chamdo was reached on July 28, about 260 miles from Jyekundo and nearly 800 from Tangar.

Officials reported that the season had been abnormally wet, and that the Ngom Chu had not been so high for thirty years: it was now an impetuous torrent. Since leaving the China–Tibet frontier the country had been well bridged. Some of the bridges were remarkably well built and rested on stone piers which withstood the great force of the rapidly flowing rivers: a vast improvement on the rope bridges of western Szechwan. The bridge across the Ngom Chu near Chamdo consists of five piers each about 22 feet square; the piers have an outer casing of wood and are filled with stones, and the roadway is supported by cantilevers.

Chamdo is a dirty little village on low ground on the narrow strip of ground between the Dza Chu and the Ngom Chu, which unite here and form the Mekong. To the north of the village are the ruins of the great Chamdo monastery destroyed in 1912 during the fighting between the Chinese and Tibetans; part of it has been restored recently.

General Pereira was delayed at Chamdo until he had permission to proceed to Lhasa, and he started on September 6 with the following retinue: his Chinese boy, a half-caste muleteer that he had engaged at Tangar, a Chinese with a fluent knowledge of Tibetan, and one Tibetan

Sketch-map of General Pereira's journey from Tankar to Lhasa.

sent by the Drepon who is the representative of the Dalai Lama in Chamdo. He had a "ula" of eighteen yaks and six horses. On September 10 he crossed the Mu La, 15,667 feet, the Mekong–Salween divide. The Tibetans, unlike the Chinese, are very good at local geography; they know what rivers the streams run into, and the names of places, whereas the Chinese are grossly ignorant of these details.

After leaving Jung-erh on September 11 he saw about 40 miles to the south a great snow-clad range called the Tu-re-la, the only thoroughly snow-covered range seen so far, with the exception of the big Amne Machin mountain.

The weather was fine after leaving Chamdo and tents were not used, as a room in a house was generally available.

Denchin was reached on September 14, the chief official here being called the Ken-jung, who has the same rank as the Drepon at Chamdo.

The Salween (in Tibetan Gia-mo-ngui Chu) was reached on September 16; its position is incorrectly marked on maps. The following day he crossed it in coracles. His two private horses had now swum the Yang-tse, Mekong, and Salween, and had forded the Yellow and Yalung rivers, no mean equine record.

He got to Shobando on September 18, and was on the main road to Lhasa described by Abbé Huc. September 24 he reached Urjien Tanda and crossed the Shiar-gung La, 16,528 feet, with 2 to 3 feet of snow at the top. It has the reputation of being one of the worst passes on the road, and the track is very steep and rocky. The mountains round were all snow covered, possibly from a recent fall. This is the divide of the Salween and Tsang Po.

Three days later he journeyed up the beautiful Nok Chu defile with magnificent views between the hills, which rise about 2000 feet above the river. The valley-sides are covered with trees, chiefly firs, and he passed through many delightful woods. The Nok Chu is a foaming torrent 30 yards wide, which was crossed twice by bridges.

On the 28th he passed a caravan of 150 horses bound from Batang to Lhasa. This and the following days he had to camp out, on the 29th at a height of over 15,000 feet, and extremely cold. He had on the 29th crossed the Nur-gung La, which he estimated to be 16,800 feet; unfortunately spirit for his boiling-point thermometer had run out. This pass, he considers, excels the Shiar-gung La in difficulty, the track being if possible steeper and consisting of large and slippery boulders.

October 2 he crossed the Banda La (Archa Pass of the Indian map); he estimated the height as 16,200 feet, the third highest pass on the road. He soon after got a fine view of the beautiful Adza Lake of light blue colour among the snow-covered mountains. The only inhabitants seen were a few nomads.

On October 3 the Tro La was crossed, and the height of the pass was estimated at 16,050 feet; the going was better and easier than that of the

previous passes, but the zigzag ascent was very steep and the top of the pass was covered with snow. This was the last of the very high passes. The description "easier" is only comparative, as the tracks over the pass and through valleys abound with large rocks and the cold at high altitudes is always very great. In addition there is the constant crossing of streams which also have their full share of boulders.

To the west of the Tro La he passed some square towers 35 to 40 feet in height, which were built when the Jung-yer Mongols or Eleuths were powerful and raided from the Koko Nor district. They were crushed by the Emperor Chien Lung, who banished them to Chinese Turkestan, where a tract of country is still known as Jungaria, and General Pereira met some of their descendants when shooting in the T'ien Shan some years ago.

Giamda was reached on October 6, a comparatively large village of forty families, of which seventeen were Chinese. The day was sunny and the scenery lovely, the evergreens mingling with the yellow tints of the autumn. There were many flowers. It was possible to get eggs and potatoes, a great luxury.

Inner Tibet is essentially a country of high mountains and deep valleys. At this time of year, except at great heights, the weather is as mild as in England in autumn, with sun most days, and there had hardly been a drop of rain since leaving Chamdo.

On October 11 he crossed the last pass of the journey, the Gungbu Ba La, height estimated as 15,300 feet, by far the easiest pass on the whole road. On October 14 his thirty-fourth stage took him to Mé-jo-kung-gar. The character of the country now changed, and he traversed a broad flat valley; the enclosing hills were lower, 500 to 800 feet, with grass and scrub and practically no trees.

On October 17 he completed the thirty-seventh and last stage and entered Lhasa, 670 miles from Chamdo, 6360 from Peking, of which over 3500 had been traversed on foot. He was the first European to enter Lhasa from China since the celebrated Abbé Huc in 1845.

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**Explanation of numerals on the accompanying map.**

The following are some of the more important notes given, at the places indicated by the figures, on General Pereira's MS. map of his route from which the accompanying sketch-map was taken:

1. Jih-yueh Shan (Sun Moon Range) is the boundary range between Kansu and Chinghai.
2. Chu-ri or Chi-da Pass (in Chinese A-mo).
3. Gunga Nor (Egg Lake) or Yün-Kai (fresh water).
4. Tong-ri-tso-nak (Lake of 1000 hills). In Mongol Butter Lake; on maps Tossun Nor.
5. Ngo-ring Tso in Tibetan means Blue Long Lake. The Mongol name is unknown.
6. In Tibetan Ma Chu, or Mother of Rivers.

7. Kya-ring Tso in Tibetan means Grey Long Lake. The Mongol name Tsaring Nor is unknown.
8. Ch'a-la Ya-K'ou (Pass) is on the Hwang Ho–Yangtze watershed.
9. Ch'a-la Shan. The Mongol names Baian-tukmu and Baian-Kara are unknown.
10. Jyekundo contains 240 families (200 Tibetan and 40 Chinese). There is a garrison of 70 Chinese cavalry, with 130 around in small detachments. The name Jyekundo or Jyeku in Tibetan, Chiehku in Chinese, officially Yüshuhsien, meaning Jade Tree City, from Tibetan name of district Yül-shul, meaning "country formed." Kansu Chinese pronounce it Yü-fu. It is inhabited by the 25 Ga-ba tribes, the district extending north to the Ch'a-la Shan.
11. 80 yards wide, deep and muddy, with strong current.
12. A note here states that the use of Mongol names is a great error. There are Mongols around Koko Nor (Blue Lake), and this Mongol name is therefore correct, the Chinese using Chinghai, which also means blue lake. Gunga Nor, a Mongol word, is also near where Mongols live. Further south there are now no Mongols, and such Mongol names as Tossun (it apparently should be To-su, meaning butter) Nor, Baian-tokmu for the great range, Oring Nor, etc., are entirely unknown to any Tibetan or Chinese. Amné Machin (pronounced by the Tibetans Anyé Măchīn) is the only Mongol name known to inhabitants. The Chinese name for this mountain is Ma-hi Hsüeh Shan.
13. Jung-erh (Rockhill's Mer Jong). Rockhill evidently took the name Mer Jong from Meru, name of the district, and Jong for Jung-erh.
14. Ngenda is Rockhill's Nyulda. It is placed too far north on the maps.
15. Denchin is Rockhill's Nar-pei-hu. The route from Denchin to Shobando has never been traversed before by a white man.
16. Shobando (officially Shumdo), an important place, with roads running north to link up with Nagchuka and Jyekundo, main road to Lhasa and Chando, and south a road by Poyul to Kala.
17. Dhari-guo (pronounced Lharin-guo, Lhari meaning Mountain of Spirits. It is the Lharugo Giachug of the Indian map, and is an important place, as the small road from Denchin comes here down the De Chu valley. The Indian map wrongly shows it as going to Sa-chu-ka. The De Chu is an important and deep river 30 yards wide.
18. As usual, streams change their names below a junction; for instance, Tro Chu becomes successively U Chu, Niem Chu, and Jya Chu at Giamda. Below its junction with the Si-arp Chu it is called the Güng-bu Zong Chu.
19. It is doubtful whether natives consider the Tsang-po Chu as the main branch of the Tsangpo, but in any case the pronunciation of the two names is the same. The Indian map calls it the Kyi Chu; everywhere the natives call it the Tsang-po Chu. At Lhasa the official name is Kyi Chu.
20. The Güng-bu district (Kong-bo of Indian map) extends from the Güng-bu Ba La on the west to Giamda, and thence south-east to Tsé-la-gong on the Tsang-po.

## ORDNANCE SURVEY

**The Second Geodetic Levelling of England and Wales, 1912–1921,** published by order of the Ministry of Agriculture and Fisheries. **Colonel Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S.,** Director-General of the Ordnance Survey. Southampton, 1921; H.M. Stationery Office, 1922. Pp. 62, *with* xlvi. *Plates. Price* 17*s.* 6*d. net.*

THE volume under review is the record of ten years' work carried out between 1911 and 1921 under the directorship of Sir Charles Close, who recently retired from the position of Director-General of the Ordnance Survey, though the programme was inaugurated by his predecessor, Colonel S. C. N. Grant. The first primary levelling of Great Britain was made between the years 1840 and 1860. It was from the nature of the case by no means up to the modern standard of precise levelling. The bench-marks were not satisfactory and many of them have disappeared, having been cut on gate-posts, mile-stones, and other sites liable to be disturbed, without much consideration being given to the stability of the underlying formation. There was also reason to think that one or two actual mistakes of the order of one foot had been made in the initial levelling, and that these had been distributed throughout the initial network by the least-square adjustment. In fact, the old primary levelling no longer fulfilled its purpose, and it was becoming increasingly difficult to close revisional levelling satisfactorily upon it. It was absolutely impossible to draw any satisfactory conclusions as to any alterations in the general ground-level, or to carry out the recommendations of the Royal Commission on Coast Erosion (1911), that steps should be taken by the Ordnance Survey to determine any relative movements of land and sea, unless the network of levelling were entirely revised and based on a primary system of bench-marks which are reasonably stable, and of which the relative altitudes are known with the highest accuracy attainable in modern practice.

The revision having been decided upon, Sir Charles Close and his assistants, Major E. O. Henrici, Lieut.-Colonel A. J. Wolff, D.S.O., and Mr. H. L. P. Jolly, M.A., Research Officer, are to be congratulated on the thorough and scientific manner in which the new programme was studied, formulated, and carried out. In 1911 Major (then Captain) Henrici had studied and tested the methods and instruments in vogue in other countries, particularly France, Switzerland, and the United States. As a result of these tests the Zeiss level No. 3 model was chosen. A great and characteristic improvement on old conservative practice was made in the levelling staff. These for ordinary use are for some reason, possibly lightness, still made of wood, a substance which not only changes length with temperature but with the hygrometric state of the air in a way which cannot be accurately allowed for. Pine rods have long been abandoned in base-line measurement, but were still in use for geodetic levelling; and in India elaborate comparisons were made before and after the day's work with a metal standard, in order to attempt to correct for these changes. In France, Mons. Ch. Lallemand had introduced as a further improvement a strip of invar connected to the shoe of the staff and running freely inside. Changes of length in the wooden casing could be read at the upper end of this at any time by means of a magnifying glass against a scale engraved on the invar strip. Lallemand's staff was at first adopted by the Ordnance Survey, but soon an improved staff was designed there and made by the Cambridge Scientific Instrument Company, in which the graduations are

painted on the invar strip, thus obviating all temperature and hygrometric corrections.

Great attention was paid to the design of a stable form of primary bench-mark. These so-called " fundamental bench-marks " are fixed at 25 to 35 miles apart, and there is always one at the junctions of circuits. They are all fixed in solid rock or in concrete on solid rock. Each has three fiduciary points, one on an external granite pillar for public use, and two—one a gun-metal bolt and one a polished flint—sunk in a covered concrete well about 3 feet deep for departmental use only. The circuits and positions of fundamental marks were planned so as to avoid, as far as possible, the softer rocks and those liable to surface changes. In the selection of the lines of levelling the successive directors of the Geological Survey were consulted. In addition to these fundamental marks specially designed bronze " flush brackets " were cemented into the face of buildings at intervals of about a mile along all the primary lines, and gun-metal bolts were let into horizontal surfaces of stone or brick at about quarter-mile intervals, but these last are not regarded as permanent marks.

The total length of the levelled lines is 3009 miles, the number of fundamental bench-marks is 86, and the number of intermediate bronze brackets is 3021.

The connection between the old level network and the mean sea-level datum at Liverpool was not precise. It was therefore decided that three mean sea-level stations should be established, and, on the advice of the late Sir George Darwin, Dunbar, Newlyn, and Felixstowe were selected. Self-recording tide-gauges were set up at these places and connected to the nearest fundamental bench-marks. The datum to which the new system of levels is referred is the mean sea-level at Newlyn, in Cornwall, as derived from the mean of the hourly readings recorded by the automatic tide-gauge there for the period of six years from 1 May 1915 to 30 April 1921.

In the reduction of the network of levelling the observed differences of height were first converted to orthometric differences by M. Lallemand's formula and the least-square adjustment was performed with these corrected differences. The network comprised eighteen closed circuits excluding the enveloping circuit, necessitating the solution of eighteen normal equations, which was carried out by the Gaussian method as developed by the late Mr. Doolittle of the U.S. Coast and Geodetic Survey. The lines were weighted inversely as their lengths, and, as the result of an elaborate investigation into the effect of accidental and systematic error on the proper method of weighting where the sides of the circuits differ much in length, this procedure was justified when the corrections were obtained. The probable accidental and systematic errors as calculated by the formulæ of the International Geodetic Association were about half the values assigned by that body in 1912 as the maxima for Levelling of High Precision. In English units the probable accidental error per square root of the mileage may be taken as $\pm 0{\cdot}0077$ foot and the corresponding figure for the old levelling as $\pm 0{\cdot}03$ foot, or about four times as great.

When the adjustment of the levelling was completed it was found that mean sea-level at Dunbar as determined by levelling from the tide-gauge at Newlyn came out 0·81 foot higher than as determined by the tide-gauge at Dunbar The calculated probable error of the levelling was only 0·16 foot, so that the actual difference was about five times as great as the probable error. As to the probable error of the mean sea-level at Dunbar as determined by the tide-gauge there, the eight years' record shows a difference of 0·191 foot between the highest and lowest annual means, while the probable annual fluctuation

is 0·038 foot. For Newlyn, with six years' record, the corresponding figures are 0·194 foot and 0·042 foot. An elaborate comparison of these variations of mean sea-level with the corresponding barometric heights has successfully demonstrated a correlation between the two, and it is estimated that about 0·12 foot of this difference is due to this cause. The residual difference is supposed to be likewise mainly due to an atmospheric cause—the effect of the prevailing winds, locally and regionally. We are thus forced to the conclusion that there is a real difference in mean sea-level between Newlyn and Dunbar, the latter being permanently raised above the former. Indications are given as to how the law of these atmospheric effects should be investigated, but it is clear that further observations over a long period will be required before we are able to calculate and eliminate their effects from the tidal record, at any particular station. The decision to base the levelling on a provisional value of the mean sea-level at one station and not to force it into agreement with the tidal observations at the other two is for these reasons amply justified.

We end by quoting the last paragraph of Sir Charles Close's Introduction :

" It is hoped that all this labour, and the large sum of money spent on the work, will be found to be justified in the future ; and it is believed that England and Wales are now provided with a primary level network which is second to none in the world, and that it will serve all practical requirements and be available in future ages for use in the study of those larger and more important problems which belong to the domain of science." A. E. Y.

## THE WEDDELL SEA

**Shackleton Antarctic Expedition, 1914-17 : Depths and Deposits of the Weddell Sea.—** J. M. Wordie. *Trans. Roy. Soc. Edin.*, **52**, Pt. iii. No. 30 (1921) ; **Geological Observations in the Weddell Sea Area.—** J. M. Wordie, *loc. cit.* 53, Pt. i. No. 2 (1921) ; **The Natural History of Pack Ice as observed in the Weddell Sea.—** J. M. Wordie, *loc. cit.* **52**, Pt. iv. No. 31 (1921).

**Die ozeanographischen Arbeiten der Deutschen Antarktischen Expedition, 1911-12.—** Dr. W. Brennecke. *Arch. der Deutschen Seewarte*, **39**, No. 1. Hamburg, 1921.

THE voyage of Filchner's *Deutschland* and Shackleton's *Endurance* added considerably to our knowledge of the Weddell Sea, which until 1912 was almost entirely based on the work of the *Scotia*. Bruce's discovery of Coats Land in 1904, approximately in lat. 74° S., long. 17° W., curtailed the possible area of that sea and threw considerable doubt on the existence of the supposed Ross deep, founded on the evidence of a single sounding. The work of the *Deutschland* and particularly the *Endurance*, on the other hand, has enlarged the Weddell Sea by showing that Morrell Land, or New South Greenland of Johnson, has no existence. The *Endurance* sailed west of its supposed position, and though Mr. Wordie admits that " there is plenty of room for an island " on the reputed site, there is no likelihood of land being found there. This discovery is important, for no previous arguments against the existence of the land were convincing. Mr. Wordie says that if Morrell's statements are to be credited the land on which he sealed must have been the east coast of Graham Land, but this is unlikely, for the ice circulation in the Weddell Sea probably makes approach to that coast practically impossible for a sailing vessel, except in a relatively low latitude.

The two expeditions added considerably to the coast-line of Coats Land

and we note that Mr. Wordie uses the name Coats Land for all that part of Antarctica on the east of the Weddell Sea, designating the different parts, Caird Coast (Shackleton), and Luitpold Coast (Filchner). It would be appropriate to apply the name Bruce Coast to the first discovered part of the coast-line north of the Stancomb Wills ice promontory. By an obvious slip in his second paper, Mr. Wordie uses the term Caird Coast for *all* the coast from 72° 30′ S. to 76° 30′ S.

Filchner showed that the Weddell Sea almost certainly does not extend south of lat. 78° S., but neither expedition saw anything of the missing coast-line of Graham Land. Mr. Wordie however comments on the sandy, as opposed to muddy, nature of the bottom deposits in the vicinity of lat. 76° S., long. 40° W. (The text has a misprint of 70 for 76.) This unusual feature in the glacial muds of the sea-floor makes it quite possible that in that region the *Endurance* was relatively near land. But no sign of land was to be seen.

Of the structure of Coats Land there is still no direct evidence. Filchner saw several nunataks of bare rock, but he could not reach them. On the Caird coast the Shackleton expedition saw nothing but ice. We have to fall back on indirect evidence from bottom deposits collected off the coast. Off Coats Land these rock fragments were granite with white felspar, basalt and dolerite not quite so abundant, a fairly common grey grit, and a rare purple sandstone. Some of the specimens recall the Beacon sandstone of Victoria Land, but Mr. Wordie holds that the material does not prove, even if it gives weight to, the prevailing idea that Coats Land is of the same structure as Victoria Land.

The oceanographical outfit of the two expeditions differed widely. The *Deutschland* was well equipped: the *Endurance*, beyond its sounding machine, had little gear and "the ship's course was never interrupted to take a sounding." In spite of this the soundings of the *Endurance* form a most important series, but unfortunately end when the ship was crushed. We note that Mr. Wordie advocates a snapper rather than a tube for automatic deep-sea work; the more useful Buchanan sounding-tube does not seem to have been employed. The soundings show a shoaling of the Weddell Sea towards the south-west, with a wide continental shelf in the south. They confirm the strikingly narrow shelf off Coats Land noted by the *Scotia*. The general trend of the contours that can now be drawn does not materially differ from those based on the work of the *Scotia* and *Antarctic* in 1902–04. The Ross deep, restricted by Bruce's sounding of 2660 fathoms on the site of Ross's 4000-fathom no bottom, does not enter the Weddell Sea, but the 2500-fathom contour sweeps far to the west in about lat. 64° to 66° S. The soundings of the *Endurance* are chiefly remarkable for the terraced nature of the south-western shelf which they reveal. The boundaries of these terraces run approximately at right angles to the supposed eastern coast-line of Graham Land. This suggests faulting and supports the idea of the plateau structure of the lands around the Weddell Sea. With the exception of the soundings on the shelf in the far south the most significant of the *Deutschland's* soundings are a series from the Weddell Sea to South Georgia, between longs. 36° and 38° W. approximately. This line crosses the ridge of shallow water discovered by the *Scotia* to extend between the South Orkneys and the South Sandwich group. The *Deutschland* series shows remarkable alternations of rises and falls between lats. 61° and 68° S., suggesting folds between these island groups.* This would seem to support the idea of the

* The excellent series of soundings of the *Quest*, so far as they are available, fill certain gaps in the bathymetry of the Southern Ocean, but throw no new light on the Weddell Sea. They confirm the Ross deep as limited on the west by the *Scotia* soundings.

Southern Antilles, that is to say, the arc of folding linking Patagonia with Graham Land viâ South Georgia, the South Sandwich, the South Orkneys, and the Powell Group (Elephant and Clarence islands). But Mr. Wordie, after discussing all the geological facts known from those islands, finds no certain evidence of the existence of such folds and looks to more detailed charting of these seas to throw light on this problem. At the same time the fact that Graham Land and South America were once connected is scarcely open to question. It is the nature and course of the link which is uncertain.

The general circulation of ice in the Weddell Sea from Coats Land towards Graham Land is now well known, and was emphasized by Mossman several years ago (*Journal*, December 1916). The sweep of the ice from the east and its lack of outlet on the west, owing to the long coast of Graham Land, make the Weddell Sea very dangerous and difficult to penetrate. These conditions obviously point to penetration on the eastern rather than the western side. Mr. Wordie suggests that the ice congestion in this sea is due to the low average wind velocity, but it seems equally likely to be caused by the relatively high latitude of the supposed coast-line of Antarctica east of long. 15° W. This would allow the prevailing south-easterlies to sweep the ice from the Biscoe Sea into the Weddell Sea. While Mr. Wordie has made a slip in writing of Bellingshausen's "discovery of land" in lat. 69° S., long. 16° E., he is probably right in suggesting a deep indentation of the coast-line roughly between long. 15° W. and long. 15° E. This would account for Bellingshausen being stopped by ice out of sight of land which is almost certainly high and visible at some distance. The same happened to the *Quest* in the same longitude. This indentation would tend to entrap ice and not allow it to escape. It may extend as far east as Enderby Land. Conditions would suggest that the exploration of the Biscoe Sea, like that of the Weddell Sea, should begin on the east.

R. N. RUDMOSE-BROWN.

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## REVIEWS

### EUROPE

**North England: An Economic Geography.**— **L. Rodwell Jones.** London: Routledge & Son. 1921. Pp. 256. *Price* 6*s.*

WITHIN the area he has chosen, which we should prefer to call Mid-Britain rather than North England, Mr. Rodwell Jones has given us a valuable study in the influences of the physical environment on the development of the industries and the modification of those influences which has been produced by changes in transport due to the introduction of canals and railways. The scope of the work is in fact somewhat more limited than the title suggests; it is concerned only with the five coalfields of Durham–Northumberland, York–Derby–Nottingham, North Staffordshire, Lancashire, and Cumberland, the iron-working districts of Tees-side and Furness, and the ports of the Humber and Mersey. The agricultural and pastoral occupations are not discussed: yet food-production is still the basic industry, though it is here overshadowed by manufactures.

The study of Hull and the Humber, which forms chapter v., is one of the best accounts of the relations of a port to its hinderland known to the reviewer. The effect of estuarine conditions on the localization of small seaports at Hedon, Beverley, and Hull (then Wyke) and the gradual concentration of the traffic on Hull as seagoing vessels increased in size is very clearly shown, as well as

the development at the port of a group of associated industries engaged in the working up of imported raw materials and requiring facilities for the wide distribution of their products, such as flour-milling, oil-extracting, and paint-making.

It is very regrettable that the book is disfigured by an unreasonably large number of minor errors, even for a first edition. For instance, on Fig. 11, p. 95, the abbreviations Bi. and Ho. refer to Birstall and Horwich, not to Birtley and Horden as stated in the key; Middlesbrough is usually misspelt "Middlesborough," and Tees-side as "Teeside." Some of the diagrams, notably Figs. 21 and 7, are by no means distinct. The railway junction shown near the middle of Fig. 13 is Trent Junction and is on the north bank, though it is named Long Eaton and shown south of the river. We hope that the preparation of a second edition will enable the author and publishers to remove these blemishes on a work which is one of the most important original contributions to the study of economic geography that have appeared in the last few years. C. B. F.

**Newcastle-upon-Tyne.— F. W. Dendy.** Newcastle. 1921. Pp. 85.

This book consists of three lectures on Old Newcastle, its Suburbs and Gilds, delivered to the Newcastle-upon-Tyne Literary and Philosophical Society in 1909, 1917, and 1921, together with an essay on Northumberland. The Society has done a real service to the citizens by publishing these lucid expositions of some of the results of investigations into the history of the city and county by many workers. We regret that the author has not added an index and the detailed references to his authorities which, though out of place in a lecture, would have made the published work of more value to the student. His method of identifying sites by reference to modern streets leaves much of the book unintelligible without a street map of the city, even to a reader who has often visited it and probably also to many residents; yet no such map is included among the ten plans here reproduced. The format of the book and the quality of the reproductions are quite up to the high standard of the publishing society. C. B. F.

ASIA

**De Zeeën van Nederlandsch Oost-Indië— Uitgegeven door Het Kominklijk Nederlandsch Aardrijkskundig Genootschap.** Boekhandel voorheen E. J. Brill, Leiden. 1922.

In 1915 the Dutch Geographical Society decided to publish a volume on the seas of the Dutch East Indies, and the work of compilation was entrusted to Dr. van der Stok, formerly director of the Royal Magnetic and Meteorological Observatory at Batavia, with the assistance of experts in the various branches of marine investigation. The delay in publication has been due to the work of collecting material for the geological section, and to the necessity of incorporating the results of the *Siboga* expedition.

Captain L'Honoré Naber has sketched the progress of discovery in the Dutch East Indies from the time of Marco Polo, the expeditions of later times since deep soundings have been taken receiving more detailed notice. Vice-Admiral Tydeman, who commanded the *Siboga* and published in 1903 the first bathymetrical chart of the area, has written the section on the submarine configuration. The temperature, salinity, density, and gaseous contents are discussed by Dr. W. E. Ringer; the marine meteorology and the tides, which are naturally very complicated in the enclosed seas of the archipelago, by Dr. van der Stok; the fauna by Dr. Max Weber; and the flora by Dr.

(Mrs.) A. Weber–van Bosse. Rear-Admiral Phaff contributes a survey of the coast, while Prof. Molengraaff gives an account of the geology, the process by which the present submarine configuration has been developed, the subsidence now in action, and the distribution and extension of the coral reefs. Each section is fully illustrated by charts, diagrams, and tables. The general results of the work of the collaborators, particularly in relation to historical geology, were set forth by Dr. Molengraaff in a paper read before the Royal Geographical Society more than two years ago (*Geogr. Journ.*, vol. 57, p. 95). The investigation of these seas is by no means complete, and there are problems connected with them which are still unsolved, but it is expected that the careful exposition here supplied of the facts already known, and of the conclusions to which they point, will make this for a considerable time a standard book of reference.

W. A. T.

AFRICA

**Reizen in Zuid-Afrika in de Hollandse Tijd.**— Uitgegeven door **Dr. E. C. Godee Molsbergen,** mit Inleiding van **R. Posthumus Meyjes.** Deerde Deel. Tochten langs de Z. O. Kust en naar het Oosten, 1670–1752.

This publication of the Linschoten-Vereeniging continues the story told in the first two parts reviewed in the *Journal*, vol. 49, p. 300. It is a collection of voyages made from Cape Town along the south coast of South Africa and as far north as Delagoa Bay, and in one case to Inhambane Bay, besides two journeys overland. In many cases the geographical results were small, partly owing to the difficulties of navigation in sailing vessels along this part of the coast where stormy winds and strong currents are met with, and also to the fact that the skippers of the small vessels which carried out this work were not trained explorers. Two expeditions deserve particular mention, the first being the voyage of the galliot *De Noord* to Delagoa Bay in 1688–9, when the bay was surveyed and a map was drawn by Cornelis Heeremans, the mate, who was probably also the writer of the account of the voyage. This map, printed by Wilhelm Blaeu, is here reproduced on a smaller scale.

The other important expedition was led by Ensign A. F. Beutler, in 1752, overland from Cape Town as far as the Key river and into Tembuland. The plan was to strike into the interior, but an English ship had landed men along the coast, and the party was diverted to the coast to prevent any encroachment on the Dutch sphere of influence. Otherwise the results obtained might have been considerably greater. Being forced to retire from Tembuland because the natives would not sell cattle, the party made an effort to penetrate into the interior with the hope of reaching the Koperberg south of the Orange river, but was stopped by the Karroo desert, and had to return by the old route. A map was compiled of which a reduced copy is inserted in this volume, and much new information was acquired of the Kafirs and Hottentots.

W. A. T.

**The Partition and Colonization of Africa.**— **Sir Charles Lucas, K.C.B., K.C.M.G.** Oxford: Clarendon Press. 1922. Pp. 228. ***Sketch-map.***

A series of lectures given by Sir Charles Lucas to "a study circle" of teachers of the London County Council is here reproduced. No one needs—and no one is likely to find elsewhere—a better summary account of the partition and colonization of Africa, while to those who already know the story this book will also be welcome for the breadth of view, lucidity, and sane judgments of the author.

The first and second chapters or lectures ably set out the reasons—largely

geographical—for the long neglect of Africa south of the Sahara by the rest of the world and for its ultimate exploitation; the last chapter, dealing with the results of the war and "African problems" (chiefly as they affect tropical Africa), deserve close study. Sir Charles Lucas holds that European intrusion into Africa was not only inevitable but justifiable, and that an outstanding characteristic of the "Negro and Bantu races" (but are not the Bantu Negroes?) of to-day is their "inability to do without European guidance." He does not deny that in some distant future the black man may become able to stand by himself, though he is doubtful about it. But the spread of Christianity and of Islam, industrial conditions in South Africa, the Negro's eager desire for education, the lessons of the war—which revealed to the black man his military worth—are factors which may produce results which Sir Charles scarcely anticipates.

Of the other chapters that on David Livingstone is masterly, as is also that on the Belgian Congo, with its sketch of King Leopold's Rake's Progress, and its conclusion that the salvation of native races is not to be found in internationalization or in governments taking part in trade. Sir Charles deals adequately with Germany's share in the partition and exploitation of Africa, and he holds that, being what she is, it is an advantage to Africa that she should be excluded from that continent.

While we may differ from some of his conclusions and inferences, Sir Charles Lucas is almost impeccable in his facts; the only slip we have noticed is however of historical importance. On pp. 82–83 it is stated that the Berlin Act of 1885 "enacted that Powers making future annexations in Africa must give due notice to other Powers and that their occupation must be effective." This is inaccurate. The articles (Nos. 34 and 35) of the Berlin Act referred only to taking possession of any portion of the African *coast;* the rule, designedly, did not apply to the interior, where "spheres of influence" were already being marked out. F. R. C.

AMERICA

**Between Two Continents.— H.R.H. Prince William of Sweden.** London: Eveleigh Nash & Grayson. 1922. Pp. xviii. and 246. *Illustrations. Price 15s. net.*

Prince William, second son of the King of Sweden, is an assiduous traveller with a taste for archæology. The present book is an account of a short visit to Central America made in 1920. The object of the visit, which was to examine ruins of the Maya civilization, was to some extent thwarted because the two scientific members of the expedition, Professor Hartman and Dr. Hemmendorff, were prevented from accompanying it by unforeseen accidents. Visits were made to Maya ruins in Yucatan at Tuloom and on Cozumel Island. The latter site seems to have escaped notice until the Prince's hurried visit. Its exact site, he says, must be allowed to remain a secret for the present. The chief interest in the book lies in the descriptions of economic and social conditions in British Honduras, Guatemala, Salvador, with some notes on the seldom-visited island of St. Barthelemy, now a French but once a Swedish possession. Prince William speaks frankly of things as he found them in Guatemala, and the account is none too flattering. Before he left the revolution of 1920 broke out, when Cabrera was deposed and Herrera elevated to the presidency. In British Honduras, and Belize in particular, he found much to admire. The book is slight and unpretentious. It was originally published in Swedish in order to awaken Swedish interest in Central America. There are several good illustrations, but no index nor map. R. N. R. B.

**The Red Book of the West Indies.**— Compiled and Edited by **A. Macmillan.** London: W. H. & L. Collingridge. 1922. Pp. 424. *Illustrations.*

This volume is an enlargement of one on the West Indies which was first issued in 1909 and ran into several editions. It deals mainly with the British islands, but includes British Guiana, Puerto Rico, and Cuba. The Virgin Islands of the United States and the Dutch West Indies receive some notice, but the French West Indies and Haiti and San Domingo are treated very briefly. The treatment is both historical and descriptive, with a large amount of statistical matter, and the illustrations are both numerous and excellent. A considerable part of the volume is occupied, in the case of all the more important islands, with a commercial gazetteer of trading firms, every one of which seems to merit a lengthy eulogy. This aspect of the book may add to its value for certain purposes, but it does not enhance its geographical significance as a book of reference. It suggests camouflaged advertising. There are no maps, which is a serious omission. R. N. R. B.

**Adventures in Bolivia.**— **C. H. Prodgers.** London: John Lane. 1922. Pp. xvi. and 282. *Illustrations.* 12*s.* 6*d. net.*

This book describes a journey made by the author to the Challana District of Bolivia, which lies between the eastern side of the Andes and the Beni river to the east of Lake Titicaca.

Perhaps the most noteworthy feature of the author's adventures in an almost completely unknown land is the fact that a man of his weight (265 lbs.) should have been able to stand so much fatigue, such great extremes of climate, such hard work, hard living, and exposure, and yet apparently to have escaped that terrible fever known as "terciana" to which all mankind, including the natives, are so prone.

The author gives an account of his journey to Lake Titicaca and La Paz over mountain passes near Sorata, and down into the tropical land of Bolivia to the rivers Challana and Tipuani which form two of the tributaries of the Amazon, so many of which rise in northern Bolivia and the eastern part of Peru. On arriving at Lake Titicaca, he takes one of the comfortable steamers *Puno* or *Guaqui*, but to those who have navigated this wonderful lake the vessels will not be recognized under these names, and it is difficult to appreciate why the well-known steamers *Inca* and *Coya* should have been so christened.

The statement is made that sheep in the neighbourhood of Lake Titicaca give 6 to 10 lbs. of wool per head; 1½ to 2 lbs. per head is nearer the true figure. It is also a mistake to say that Alpaca prefer the flat ground near the lake, while sheep more generally frequent the higher ground; the opposite being the case. The statement that the Indians are easy to get on with if properly treated is corroborated by many of those who have lived amongst them. Unortunately the treatment of the Indians by the descendants of Pizarro and his followers has been one long record of injustice and cruelty. That this part of the world is no place for the white labourer is confirmed by all those well acquainted with Bolivia. Only the ordinary wages of the Indian can be obtained by the white labourer.

The author had several long shots with the rifle at condor on the wing, and those who have seen condor on the wing in these regions will not be surprised that neither he nor his servant was able to find any trace of the wounded bird.

For the rest the book is a readable account of an adventurous journey, without any particular scientific or geographical value. It is to be regretted that the author provides no map to show even roughly the route taken by him,

the more so as most atlases do not indicate the whereabouts of Challana or Tipuani. The loss of the numerous photographs taken by him leaves the book with but a few stereotyped photographs and some very indifferent coloured sketches.

## POLAR REGIONS

**The Worst Journey in the World.— Apsley Cherry-Garrard.** 2 vols. London: Constable & Co., Ltd. *Price* £3 3*s*.

The title of this latest and in many ways most valuable addition to Antarctic literature refers particularly to the mid-winter journey made by Dr. Wilson, Lieut. Bowers, and the author from Cape Evans to Cape Crozier in July 1911. The book, however, is also a record of Captain Scott's last expedition, and the Cape Crozier journey itself forms only a portion of the two volumes. Those who have read 'Scott's Last Expedition' will of course find much that they are already familiar with, but Mr. Cherry-Garrard has succeeded in investing an old story with fresh interest and vigour. Though an active participator in most of the events recorded, he can still write more or less as an onlooker; and his judgments and comments on the methods and performances impress one as thoroughly sound and unbiassed.

The first volume describes the early events of the expedition, the voyage out from England, the autumn depôt journey and life at winter quarters. It begins with a racy introduction; it ends with a complete account of the terrible winter journey to Cape Crozier. Mr. Cherry-Garrard is now the only survivor of the party of three who accomplished a trip certainly without parallel in the South Polar regions. Equipment and rations, adapted by Scott to the Antarctic and considerably improved by Shackleton, are considered fully adequate for summer sledging. On this occasion they were used experimentally on a winter expedition. The journey was successful and the party returned; but the author makes it quite clear that, if such a trip is to be repeated, it can only be done with other methods. It was on the smallest of margins that he and his companions pulled through. In the intense cold and bitter wind of winter their clothing was insufficient and their tent a far too meagre shelter. That they ever returned alive to Cape Evans seems almost incredible, and the story fills one with nothing but admiration for these three resolute men.

The second volume deals with Captain Scott's fatal journey to the Pole. Quotations from the leader's diary were inevitable, but the author has tried wherever possible to base his account on extracts from Dr. Wilson's and Lieut. Bowers' unpublished diaries. His own, written at the time, forms of course the groundwork. By judicious selection of the material monotony has been avoided, and the present narrative carries us on rapidly from one incident to another on the various journeys. There is only one drawback, namely that the maps seem hardly adequate. The illustrations are numerous and well chosen; and an unusual feature are the large panorama drawings made by Dr. Wilson on the southern journey.

Mr. Cherry-Garrard holds very decided views on Antarctic travel. In his own case he says that he went beyond his strength, and may feel the effects permanently. He feels therefore that future explorers should know what were the advantages or the drawbacks of the Scott equipment. Sledges, condition of snow, food, and clothing are all commented on and various improvements suggested. In one particular case, that of food, he states definitely that the Scott "summit" ration, good as it was, was nevertheless insufficient for such a prolonged journey at low temperatures. He considers that the steady loss

of condition which appears to have resulted was the real cause of Captain Scott and his companions failing to reach One Ton Depôt. If this is the case it is highly desirable that experimental work on the ration question should be done at once before another expedition is attempted. Mr. Cherry-Garrard, by calling attention to such matters as these, is rendering great service to the cause of polar exploration which he has so much at heart. J. M. W.

## MATHEMATICAL AND PHYSICAL GEOGRAPHY

**The Climates of the Continents.— W. G. Kendrew, M.A.** Oxford: Clarendon Press. 1922. Pp. xvi., 387. *Maps and Illustrations. Price 21s. net.*

This comprehensive survey within moderate compass of the mainland climates of the globe is heartily to be welcomed since, with the exception of the incomplete translation of the late Dr. Hann's 'Klimatologie,' and Prof. Ward's 'Climate' published in the United States, there is no work in English of the kind extant. It is all to the good, too, that the author should be a geographer well versed in the principles of meteorology, seeing that more specialized meteorologists frequently miss the broader views and fail to give the illuminating touches when they deal with those regional and seasonal distributions of atmospheric conditions the study of which constitutes climatology. A somewhat undue amount of space is perhaps allotted to the discussion of temperature and rainfall, important though these are, whilst certain other elements of climate receive scant notice; yet the general treatment is excellent from the standpoint both of description and explanation. One regrets, however, to find two anomalous dry regions near the equator inadequately accounted for, namely the Benadir coast of Somaliland (p. 44), and the São Francisco region in the eastern shoulder of Brazil (p. 328). The fundamental reason of the drought in Italian Somaliland is the complete subversion of the normal equatorial circulation effected by the great summer monsoon system of Asia, which prevents the convergence of air-streams from the opposing Trades upon which the Doldrum rains depend. The dry region behind the eastern projection of Brazil has been a long-standing puzzle, and, as Mr. Kendrew observes, cannot primarily be due to position to the lee of the coastal ranges inasmuch as the coast itself, obstructing the moisture-laden trades, is unusually dry. But one only needs to study the circulation of the region as depicted on quite familiar maps to obtain evidence that the south-east Trade current, like the south Equatorial ocean current beneath it, is split in two branches by the wedge-like projection of the Brazilian highland; and it is a fundamental principle in meteorology that divergence of air-streams spells dryness.

Much attention is paid to the physiological significance of relative humidity, although the researches of Dr. Leonard Hill have shown that, except at the point of actual saturation of the air with wetting fog, it is absolute humidity which is the really important condition in controlling evaporation from the skin. The rate of evaporation is controlled by the difference in the vapour tension of the air, and that just at the evaporating surface, and it is only when the surface and the air are at the same temperature that the rate is related to relative humidity, which in that case becomes a measure of the absolute humidity. An atmospheric condition common in England in mid-winter, when there is an influx of warm moist air from the Atlantic, is connected with a high vapour tension, the relative humidity being more often than not 10 per cent. short of saturation, and no higher than may occur with a severe frost, when the air feels dry. On the other hand, the oppressive sultriness of certain days in

summer, due to a higher vapour-content and dew-point temperature than ever occurs in the damp winter type of weather, may be associated with a comparatively low relative humidity—down to 70 per cent. or below.

It is satisfactory to note the author's insistence on the importance of studying the geographical distribution of sunshine in relation to temperature. But the abundant records of sunshine-duration which exist in many countries are lamentably inadequate as giving no indication of the quality and intensity of the sunshine, and it is to be hoped that they will gradually be superseded by radiograph records of the amount of energy received from the sun in a given time. We shall thus discover the fallacy of supposing, for instance, that a day with an air temperature of 90° F. in England is thermally comparable with a day of the same temperature in Italy.

Throughout the book the medical note rings loud, and there are some vivid passages in regard to the deadliness of the "West Coast." The problem of tropical climates is no doubt far deeper than the suppression of ravaging epidemics by stringent sanitary measures. Unfortunately, the medical aspects of climatology present extremely complicated questions owing to the difficulty of disentangling the direct influences of climate from their interaction with economic, hygienic, and deep-seated sociological factors.

Mr. Kendrew's excellent work has one serious drawback in the absence of adequate references, when statements are made upon doubtful or controverted points. Thus, on p. 217 the statement that in the south of England September is the only month when the average amount of cloud drops to 60 per cent. is not easily harmonized with the fact that in this country the average meteorological sunniness, or percentage of its possible duration, runs closely parallel with the astronomical sunniness, or length of day, so that in actual daily amount the equinoctial periods are intermediate between the solstitial. Again, on p. 232, it is very ambiguous to state that at Geneva, a locality within the West European zone of intermittent snow cover, in an average winter snow lies on the ground for a fortnight, because the aggregate number of days in the course of a winter must amount to much more than this, and the time of occurrence of anything approaching a regular continuous fortnight must be very uncertain. Finally, with reference to the cold, damp winter fogs of the bottoms of Alpine valleys we should have expected some comment on the following quotation from Maurer: "It is especially in November, December, and the first half of January that the higher stations enjoy the greatest climatic advantages, that is to say, when the days are shortest." But why stop with mid-January when the days are shorter than in mid-November? It is only that, in consequence of the equation of time, the afternoons are unduly dark in November, and the mornings in January.

The book is well furnished with maps and diagrams; but it is surely unnecessary for purposes of visualization to render so many figure tables of seasonable variation of elements in diagrammatic form. L. C. W. B.

**Man as a Geological Agent.— R. L. Sherlock, D.Sc.,** etc. London: H. F. & G. Witherby. 20*s. net.*

In this book Dr. Sherlock has collected a vast amount of information concerning the effects of man's activity in transporting material, both horizontally and vertically, from one part of the Earth's crust to another. The greater part of such activity may logically be included under the term "denudation," and the conclusion is reached that "in a densely peopled country like England man is many times more powerful, as an agent of denudation, than all the atmospheric denuding forces combined. In proving this statement the author has

amassed, by means of prolonged research, a number of figures dealing with such obscure points as the amount of stone reduced to powder by traffic on the roads; and it would be ungrateful to complain because he has confined himself almost entirely to England or the British Isles. Only in such a civilized country could his estimates be more than rough guesses; but, on the other hand, it must be remembered that his carefully calculated estimates are necessarily maxima, and that man's geological agency is zero over wide tracts of the Earth's surface.

Dr. Sherlock's method is to give in each section a concrete example, usually one of which he has personal knowledge, followed by calculations based on statistics published in the Home Office Reports or elsewhere. Thus, he illustrates the removal of chalk by taking an area in Buckinghamshire and estimating the number of pits sunk to obtain chalk for marling the land; perhaps a more striking example is to be found in Kent, either between Dartford and Gravesend or in the lower part of the Medway valley, where the Portland cement manufacturers' many huge pits have materially altered the topography, though of course the amount of chalk used in cement-making finds its place in his calculations.

Many of the subjects dealt with are, as the author points out, as much geographical as geological; he gives a most interesting and well-illustrated account of the subsidence produced by the mining of salt and the pumping of brine in Cheshire and the consequent formation of "flashes" or lakes; the bottom of one such lake is known to have reached sea-level already. Again, the interference of man with the natural flow of water and the relation of drainage areas to one another is essentially a geographical subject. Many people are aware that the bulk of the waters of the Vyrnwy, instead of joining the Severn, are diverted to Liverpool and enter the Irish Sea instead of the Bristol Channel, but it has been left to Dr. Sherlock to deal with the subject of such diversions comprehensively; his map of part of the Pennines showing areas taken by man for water-supply is most instructive.

Some parts of the book necessarily make rather dull reading, but they are really the most valuable. When a new edition is called for a few printer's errors in the tables of figures should be corrected; but the results are likely to need little alteration in future years, except, perhaps, those concerned with the consumption of petroleum, which are given only down to 1908; the world's output that year was about 40 million tons, whereas in 1921 it reached some 100 million.

A copy of this book should be found in all scientific and reference libraries.

C. N. B.

**Tides and Tidal Streams.— Commander H. D. Warburg, R.N.** Cambridge University Press. 1922. Pp. 84. *Illustrations and Appendix of Nine Tables. Price* 8*s.* 6*d. net.*

Commander Warburg has had a wide experience as Superintendent of Tidal Work, Hydrographic Department of the Admiralty, and has set out in this manual his own views on the causes of tidal phenomena and their prediction, advocating the use of harmonic constants in the tide tables instead of, or in addition to, the non-harmonic constants now given.

The whole subject of tides is fully dealt with; the origin of the lunar and solar waves with their contained semi-diurnal and diurnal portions. The building up of the tidal wave at any place from partial but unvarying waves, and the dependence of the height of the compound tidal wave at any moment upon the heights of these partial waves is clearly set forth.

Chapter i. deals with the tide-raising forces, and in the following chapter the tides as they actually exist are considered. In paragraph 23, chapter ii., the relation of wave speed to depth of water is expressed in a formula which is not quite correct, as the square root sign should not appear over the depth, evidently a clerical error as the result given is correct.

The method of tidal prediction by means of non-harmonic constants is explained in chapter iii., where it is shown that this method may be used for places where the diurnal partial waves are small in proportion to the semi-diurnal, as in most European waters. It is indicated that the fundamental difference between the so-called non-harmonic and the harmonic method advocated by Commander Warburg lies in the fact that in the former the compound wave is considered as a whole while in the latter the component partial waves are dealt with separately. The method of prediction in which the compound wave is treated as a whole is criticized on the basis that in fact it does not behave as a single wave, but each partial wave is subjected to influences which depend on obstructions and irregularities in the coast-line and sea-bed and on varying depth of water at different states of the tide. Heights obtained by means of constants assume that diurnal, anomalistic, and declination inequalities do not exist, and that the semi-range of solar to lunar semi-diurnal partial waves is as 1 : 2·73, whereas the inequalities do exist and the ratio $s : m$ varies in European waters from about 1 : 7·8 at Wilhelmshaven to 1 : 2·0 at Gibraltar. The harmonic method of prediction is summarized by Commander Warburg as :

(*a*) The division of the true tide wave, as obtained from observations, into a number of simple waves.

(*b*) The re-combination of the simple waves into the tide wave as it will exist at a future time.

In chapter v. the methods of finding the height of the tide at times between High and Low Water are dealt with and illustrated by examples. There is much useful information in this chapter.

In chapter vi. exact tidal predictions are discussed, and the effect of meteorological conditions. The effects of atmospheric pressure and wind on the height of the tide is, however, not very clearly dealt with, and these deserve more attention than they usually receive. It is stated that " The height of the tide is usually increased by an abnormally low barometer and by on-shore winds " (p. 46, para. 73), but the water-level is affected not only by an abnormally low pressure but by all the changes of pressure, especially if fairly local, and the most profound effect of wind is probably when it blows into the open mouth of a sufficiently long, narrow body of water otherwise surrounded by land.

Page 69, para. 112, describes the motion of the particles in deep water waves as " entirely vertical," which is somewhat misleading since it is well known that there is also a horizontal oscillation which produces a maximum horizontal velocity at the mid-point of the wave slope. The discussion on tidal streams in this chapter is interesting, and the terms " flood " and " ebb " streams are very reasonably criticized. It is suggested that the streams might, with advantage, be known by the direction in which they run, such as " in-going " or " out-going," " north-going."

A number of useful tables relating to tidal work are given in the appendix. The book should be studied by those interested in tides as well as by seamen, for whom it was compiled. The absence of an index is unfortunate.

J. S. O.

GENERAL

**Coal in International Trade.**— **A. J. Sargent.** London: King & Son. 1922. Pp. 73. *Price 2s. 6d. net.*

This little book contains a valuable summary of the main facts bearing on the world's coal trade and power resources at the present time. We may note particularly the statement on page 9 that 90 per cent. of the coal production is obtained in nearly equal amounts from the two great industrial regions of Europe (including Britain) and the U.S.A., and on page 10 that the coal which crosses international boundaries, and so appears in statistics of imports and exports, is less than 15 per cent. of the world's total. Coal is a heavy and bulky commodity which can be most economically used within fairly easy reach of the mines, and its importance in international trade is mainly an indirect result of its use in manufacturing industry. Professor Sargent devotes a large proportion of his space to a comparison of the conditions, geographical and economic, of the coal trade in Britain and the U.S.A. down to 1921, and concludes with a review of the position and prospects of water power and oil as possible alternatives to coal in industry. Students of economic geography cannot afford to miss this book. C. B. F.

**The Track of the "Typhoon."**— **W. W. Nutting.** New York: Motor Boat Publishing Co. 1922. Pp. xvii., 270. *Illustrations and Chart. Price* $2.

The *Typhoon* was a small ketch, in which Mr. Nutting and two companions sailed from Baddeck, Cape Breton Island, to Cowes, in July and August 1921. The crossing, which was fairly uneventful, occupied 22 days. The return journey was made *viâ* Roscoff, Ferrol, Coruña, and the Azores. Heavy gales in the Gulf Stream region sorely tried the little vessel, but, well designed and ably handled, she successfully weathered them and reached New York about a month after leaving Ponta Delgada. The *Typhoon* was designed and built for the task. She was 45 feet long, and had about 950 square feet of canvas. A single-cylinder $7\frac{1}{2}$ h.p. motor was fitted for auxiliary use. The author is careful to point out that there was no serious motive behind the cruise: "We did it for the fun of the thing, and we believe that no further explanation is necessary." *Typhoon's* was a pleasure cruise on the part of men who love action and risk and hardship for their own sake. This is the spirit that has prompted all high adventure by sea or land from Equator to Pole. Mr. Nutting and his friends do not even proffer an excuse for their adventure, the customary apology to the utilitarians. The joy of doing was enough for them. American yachting, Mr. Nutting believes, needs less common sense, fewer restrictions, and more sailing. These limitations only emasculate a sport. He wants to see more sailing in all weathers, more of the British love of the sea; more of the prayer that it will "blow like hell." The volume may have little geographical significance, but it is a volume to read and enjoy, full of courage, laughter, and good comradeship. R. N. R. B.

**Naval Operations** (Official History of the War).— Vols. 1 and 2. **Sir Julian S. Corbett.** London: Longmans. 1920 and 1921.

Although of course primarily intended for the student of naval history, these two volumes, dealing with operations in all parts of the globe, are of considerable geographical interest. The period covered by vol. 1 extends from the outbreak of the War to the battle of the Falkland Islands, while vol. 2 takes

the story onwards as far as the landing at the Dardanelles in April 1916, and the progress of the German submarine campaign up to the time when the *Lusitania* was sunk. Vol. 3, which has not yet appeared, is to include the opening of the Salonica operations, the operations at the Dardanelles from the Suvla landing to the evacuation, the Mesopotamia campaign down to the capitulation of Kut al Amara, the commencement of the extended German submarine campaign, and the battle of Jutland.

Even if he had written nothing else upon the subject, the two volumes now under review would have been amply sufficient to establish their lamented author's reputation as a naval historian, and to emphasize the regret which his readers will feel that the completion of the work must necessarily be entrusted to other hands. Written so soon after the events which it narrates, it is of course unreasonable to expect that it should be regarded as the final authority upon its subject, but as a lucid, orderly, and as far as may be unbiassed exposition of events and operations enormous in scope and highly complicated in detail, it challenges comparison with the best historical work of any period.

Sir Julian Corbett was careful to explain that while he was given access by the Lords Commissioners of the Admiralty to official documents, he alone was responsible for the presentation of the facts and for the interpretations placed upon them. The style of the book, at once personal and dispassionate, renders such a caveat almost superfluous. He has taken the dry bones of his subject and clothed them in a manner which renders them extraordinarily readable and attractive. "Official histories" generally read like state papers, written by officials for officials, but while the naval operations of the war would probably retain some interest for the general reader even if narrated in the style of the Statutes at Large, his attention is here put to no such extreme test, or indeed to any test except that of appreciating the true significance of the panorama which is so easily and smoothly unrolled before him.

Any work of the kind would of course be incomplete without maps and charts, and these are supplied in good measure in vol. 2. They comprise maps of all the principal seats of naval operations, plans of some places of special interest, such as the Dardanelles, the Suez Canal, Smyrna, and Alexandretta, and a series of stategical charts of various notable operations, including the raid on the Yorkshire coast, the battle of the Dogger Bank, and the search for and destruction of the *Dresden*. R. T. G.

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## THE MONTHLY RECORD

### EUROPE

**The "Gouf" of Cape Breton.**

THE much-vexed question of the origin of the remarkable submarine channel which prolongs the line of the river Adour beneath the Bay of Biscay and is known as the "fosse" or "gouf" of Cape Breton, is once more discussed, by Commandant C. Gorceix, in a paper in *La Géographie* for April of last year. It has been a tempting notion to regard this trench as an old river channel, eroded in an old land surface which has since sunk beneath the ocean. This view was adopted, it will be remembered, in a paper read before the Society twenty-four years ago (*Journal*, vol. 13, p. 285), by Prof. E. Hull, though in the discussion which followed several of his fellow-geologists, more cautiously minded, expressed grave doubts whether a sinking of the land to the extent

of some 9000 feet, necessitated by the theory, could be substantiated. Commandant Gorceix too gives weighty reasons against the acceptance of any such theory. He shows that no other river valley of Western Europe is continued by such a submarine trench as must be found if any such general sinking of the sea-bottom took place, but that they (and even the Adour itself) rather form cones of dejection outside their present mouths. A chart of the sea-bottom in the locality of the *gouf*, in which the contours are drawn at regular intervals on the basis of the available soundings, shows nothing like the longitudinal profile of a normal river valley near its mouth, but a quite irregular fall presenting the typical aspect of "karst" conditions. If the contours are drawn for the whole coast region wherever there are sufficient soundings the same aspect is reproduced, a number of separate depressions, generally about a kilometre in diameter, being revealed. When these depressions reach the continental shelf they form trenches, following the direction of the original fractures which may have helped their formation, namely one parallel to the coast of Spain. There appears, in fact, to be a submarine continuation of the nummulitic sandstones near Biarritz, in which grottoes are also excavated where they occur above sea-level. In 1912 MM. Dubalen and Martel explained the *gouf* as associated with a line of fractures by means of which a subterranean stream of warm water might pass under the sea and keep the *gouf* free from deposits by the convection currents thus set up. M. Gorceix dissents from this view for what appear to be cogent reasons, and thinks that we have to do either with a tectonic accident accompanied by submarine subsidences helped by the super-position of the nummulitic sandstones on the clayey strata on which they rest, or, more probably, by the solution of the gypsum and rock-salt contained in a vast saline basin extending along the Cantabrian coast.

**The Amsterdam-North Sea Canal.**

The work now in progress for the deepening of this canal has given occasion for the issue in Amsterdam of a 'Short Description' in which the history of the undertaking from its inception in 1865 is given in outline together with an account of its present condition and the improvements to be brought about. Before 1825 all ships leaving Amsterdam for the North Sea had to navigate the Zuider Zee, with its depth of at most 3·50 metres. In 1825 access was given to the outer sea by a canal through the province of North Holland to the port of Niewediep near Helder. This had a depth of 5 metres. The new direct canal to Ymuiden, begun in 1865 and completed in 1880, was made by cutting through the line of dunes fringing the North Sea, and dredging and building dykes along the course of the Y, which itself communicated with the Zuider Zee both directly and through a dyke with locks. At Ymuiden a harbour was formed by the construction of converging breakwaters, and this communicated with the canal by means of locks, the depth in the latter being 7·50 metres below the Netherlands Survey datum level, and that of the fairway in the harbour 8·50 metres. Between 1899 and 1907 the increasing size of ocean-going ships led to the deepening of the canal to 10·30 metres, with a minimum breadth of 50 metres at the bottom, and the making of a new lock at Ymuiden 225 metres long and 25 metres wide. The previously existing railway bridges were also replaced by revolving swing bridges. The water from the surrounding polders is discharged into the canal to a maximum (in wet seasons) of some 9 million cubic metres in twenty-four hours, and water also enters from the Zuider Zee. The level is kept so far as possible at 0·50 metre below the Survey datum either by discharging the surplus water during ebb tide at Ymuiden by means of an evacuating lock, or by pumping into the

Zuider Zee. Two ice-breakers permit the fairway to be kept open even in intense cold. Ships are admitted to the canal to a length of 220 metres, a breadth of 24 metres, and a draught, if the canal is at its normal level, of 9·20 metres. Their passage through the locks is dependent on the state of the tide. Between 1877 and 1913 the gross tonnage of ships passing through the canal locks in both directions rose year by year (with only an occasional slight set-back) from 1,376,781 to 27,949,733. The various parts of the canal are minutely described and illustrated by photographs and diagrams, the latter of interest mainly to engineers. There is also a large-scale map. The works now in progress will result in a further enlargement, the depth being increased to 15 metres below ordinary level and the width at bottom to 100 metres. A fourth lock is to be built at Ymuiden with a length of 400 metres and a width of 50 metres, or half as wide again as the Panama Canal locks, making it the largest lock in the world. This will permit the entry of ships with a draught up to 13·80 metres.

## AFRICA

### The Crossing of the Sahara by Motor.

M. Haardt's spirited project to cross the desert from Algeria to Timbuktu in five Citroën cars fitted with caterpillar attachments on the Kegresse-Hinstin plan was put into execution on December 18, and has proved a complete success. A start was made on that date from Tugurt, the terminus of the railway south of Biskra; and from that point the cars proceeded to Wargla and Insalah, whence the more arduous portion of the traverse was begun. On January 9 news was telegraphed from Paris that all the party had reached the Niger river on the 4th and entered Timbuktu at 10 a.m. on the 7th, without any casualty; the last stage of the journey, from Burem to their destination, being accomplished in twenty-seven hours without a stop. The expedition, headed by M. Haardt (Director of the Citroën Factory) and Lieut. Audouin-Dubreuil, formerly a military airman, included Lieut. Estienne of the French Air Ministry and M. Paul Castelnau (a scientific observer) and a mechanic. They encountered many difficulties on the way, including a sandstorm and an attack by wandering Arab banditti; but all the members arrived in good health and were accorded an ovation by the population of Timbuktu. Despite the difficult nature of the ground, such as sand drifts, boulders of bare rock, and far-stretching waterless tracts of desert (in the main instance 812 miles in extent), the cars gave no trouble, and arrived, the reports state, in first-rate condition, after covering nearly 2000 miles—an average of 100 miles a day. This achievement marks a novel stage in the development of travel and geographic exploration; and also affords a remarkable example of human ingenuity, perseverance, and ever-progressive mechanical skill, of which France may well feel proud.

### Scientific Expedition in Eritrea.

An Italian expedition for scientific research in Eritrea is being undertaken by Dr. Guido Corni, Dr. Cesare Calciati, and Signor Luigi Bracciani, the second of whom is known for his previous scientific work in the Karakoram. The expedition, which has influential support, will start by way of Barentu and devote itself to geographical, anthropological, and natural history researches in the Kunama country between the rivers Gash and Setit, which is still imperfectly known, and it is proposed to come out by way of Kassala in the Egyptian Sudan.

## AUSTRALASIA AND PACIFIC ISLANDS

### Wireless Meteorological Station on Willis Island off the Queensland Coast.

An idea that had been under consideration for some time was carried into execution towards the end of 1921 by the installation of a wireless station on one of the small Willis group of islets lying outside the Great Barrier Reef off the coast of Queensland, about 250 miles eastward from Cairns. The site was selected as lying on the usual path of cyclones which strike the Queensland coast, and the purpose of the station is to give warning of the approach of storms some twenty-four hours before such indications can be given by stations along the coast. Following on the report of one of the Commonwealth engineers who had made a tour of inspection in June 1921, a small steamer was chartered, and conveyed to the south-west islet of the group the huts specially designed for the operators, together with the necessary instruments and stores. The work was completed on November 7, the steamer then returning and leaving on the island two wireless operators, as well as Capt. J. K. Davis, Director of Commonwealth Navigation, who in addition to the meteorological observations hoped to make a special study of the tidal phenomena. A survey of the islands was also contemplated, and the necessary equipment taken for the purpose. The island is completely bare, except for the growth of a kind of sea grass, but is the home of a vast number of birds.

## POLAR REGIONS

### Captain Amundsen's Arctic Projects.

Now that Captain Amundsen's vessel, the *Maud*, has at last started (though without the leader) on the drift across the North Polar Basin originally planned fourteen years or more ago (*Journal*, vol. **33**, pp. 440 *et seq.*) it may be useful for future reference to recapitulate the various stages of the adventure from the beginning. Amundsen's plans have so often been made, abandoned, and remade, that for some years we have hesitated to comment upon them, as it seemed impossible to say anything which might not be out of date almost as soon as printed. But with the actual besetment of the vessel in the ice north of Eastern Siberia one part at least of the programme has been put beyond the possibility of recall.

Having completed the outfit of the *Fram* for the proposed Arctic voyage Amundsen sailed from Kristiania on 13 June 1910, ostensibly for the purpose of carrying out the plans previously announced, and it was only after the ship was well on her way to the Antarctic that the public was made aware that all had been changed in favour of the dash for the South Pole which turned out so completely successful. After the return from the South the original project was resumed, and, having secured substantial financial support both at home and in the United States, the promoter proposed to make the final start from the Pacific coast during the summer of 1914, the *Fram* being taken up by way of the Panama canal (*Journal*, vol. **41**, p. 594). Landslides in the Culebra Cut, which caused an indefinite postponement of the opening of the canal to traffic, made it impossible for the *Fram* to reach Bering Strait by the time arranged, and the start was put off till 1915. Then came the Great War, and a further indefinite postponement, the interval being however utilized for completing the equipment, and particularly for the building of a new vessel, named the *Maud*, specially constructed with an egg-shaped hull to resist the pressure of the ice. She is a fore-and-aft schooner of 900 tons register, shorter but broader than the *Fram*, with auxiliary oil engines of low power. Meanwhile the

original plan was so far changed that it was proposed to reach the starting-point for the drift by way of the Kara Sea and the coast of Siberia instead of by Bering Strait. The voyage would therefore be more or less a repetition of Nansen's, only an attempt would be made to begin the drift farther east than the starting-point of the *Fram*. Aeroplanes were to be taken in order that the site of the Pole might be reached by this means should the ship not pass near it.

Eventually a start was made in 1918, Yugor strait being entered on August 19, Dickson island reached on the 31st, and the voyage continued to Cape Cheliuskin, where it was found necessary to go into winter quarters. Only in September 1919 was the ship freed from the ice and the voyage resumed. After passing south of the New Siberia islands an attempt was made to push north, but the pack was found to be drifting southwards, and it became necessary once more to go into winter quarters near Ayun island off Chaun bay. In July 1920 the ship was set free and Amundsen sailed for Nome in Alaska, intending to return to the neighbourhood of Wrangel island in the autumn and there begin the drift. He sailed from Nome on August 8, and according to news received in June 1921 reached the neighbourhood of East Cape, where the *Maud* was once more frozen in. Returning to Alaska to refit, she sailed north again in 1922, leaving Point Hope on July 26. On the 28th Amundsen appears to have left the ship with two companions for Point Barrow, having decided to attempt an aeroplane flight across the Polar basin. The *Maud*, under the command of Capt. Wisting, continued the voyage to the north-west, meeting the first ice in 70° N. and sighting Herald island on August 7. Winter came early, and the ship was frozen in on August 22 and drifted variously until on December 15 she was in 73° 20′ N. in the longitude, according to the wireless telegram received *viâ* Spitsbergen, of 173° W., which may be a mistake for 173° E., as the previous drift had been due westerly. The ship was severely nipped on September 26, being lifted 2 feet, but came through the ordeal without damage. Fine weather had been the rule, and the scientific work—kept in view throughout as the main object of the voyage—was being carried out systematically.

## GENERAL

### The Geography of Fairs.

In the *Journal* for May 1922 (p. 393) we referred to a recent Italian study of the fair of Pinerolo, on the Italian border of the Alps, a typical example of the old-established fairs which once played so important a part in the economic life of the world. This has been soon followed by a more general study of fairs from the geographical point of view, contributed to the October number of the *Geographical Review* by Mons. A. Allix of the Institut de Géographie Alpine, Grenoble. This writer divides fairs into two groups of two members each, which, though often existing side by side or in combination, are fundamentally distinct and probably go back to two different origins. The one group includes the general commodity fair and the recently created sample fair, the other the town-market and live-stock fair. Among primitive people, commodity fairs mostly represented a meeting on neutral ground between more or less hostile parties. A certain periodicity is imposed by the variation of the seasons and the intermittent character of the commerce, maintained chiefly by caravan. Coincidence of the fair with a feast augments its chance of success, though it is far more dependent on the physical conditions. In the middle ages, when many fairs were legally guaranteed and frequented by international merchants, it was the French fairs of Champagne and Flanders

that long played the principal *rôle*, the golden age of German fairs coming later, while the eastward movement was continued by the development of the fairs of Russia, the Balkans, and Asiatic Turkey for the interchange of goods between Europe and Asia. M. Allix lays less stress than some writers on the periodicity of the fair as its fundamental trait, attaching more importance to its location on a frontier, and to its essential nomadism. Fairs were located chiefly at the centres of producing regions (*e.g.* that of the textile industry of Flanders) and in places of transit, especially cross-roads. The connection between fairs and towns was usually but slight, the fair being under an entirely distinct administration, with its own police, bankers, and middle-men. Hence great fairs have often been associated with small towns. Modern conditions have lessened the importance of the general commodity fairs, restricting them more and more to special commodities, such as furs, for which there is a seasonal sale, and which cannot be bought by sample. Live-stock is such a product, and the stock fair still flourishes in Western Europe, sometimes as a mere survival from the general fair, but more often as an independent organization which coexisted with the general fair, or is possibly still more ancient. Pastoral nomadism has a rhythm inseparably connected with the rhythm of the seasons, and the fair becomes to it a permanent necessity. The western Alps offer a striking example of the economy of the stock-fair, and the sketch-map given by M. Allix shows how the fairs are distributed throughout the region in accordance with the natural zones into which it may be divided. The specially important fairs, which collect for export from the smaller fairs and distribute the live-stock to a distance, lie round its outer border. Such is the fair of Pinerolo on the Italian side, the chief importance of which lies in this very character. Even the stock fair, however, shows signs of slow decadence, whereas the newly organized sample fairs, such as those of Leipzig and Lyon, to which M. Allix devotes special attention, seem likely to become increasingly important. They have revived many of the features of the old commodity fairs, *e.g.* their large measure of independence of the towns in which they are held. At the outset the Leipzig fair has been concerned chiefly with facilitating export from an economic domain of limited extent, but there are indications that the fair may also include the function of provisioning the surrounding region with its requirements, thus forming a sort of inland port satisfying both the import and export needs of its economic domain.

**Honour to Mr. Reeves, the Society's Instructor in Surveying.**

We record with pleasure the award to Mr. Reeves of the "Cullum" Gold Medal of the American Geographical Society for 1922. It is given in recognition of his services to geographical surveying, and the new standards in the field of scientific exploration which he has created by devising and improving instruments and methods. The American Society has also shown its appreciation of this Society's School of Surveying, directed by Mr. Reeves, by sending for instruction under him a young American, Mr. Weld Arnold of Harvard, with a view to the establishment of a similar school under the auspices of the American Geographical Society; a scheme in which our Medallist, Dr. Hamilton Rice, Vice-President of the latter Society, is keenly interested. Meanwhile another pupil of Mr. Reeves, Lieut. O. M. Miller, who took this Society's diploma last November, has gone to New York to take temporary charge of the proposed course of instruction.

**Centenary of Weddell's Voyage.**

In celebration of Captain Weddell's attainment of 70° 15′ S. lat. on 20 February 1823, it is proposed to hold a gathering of Polar Travellers in Cambridge on Tuesday, 20 February 1923. Those attending will visit the Scott Polar Research Institute in the afternoon, and will dine in the evening at St. John's College. No formal invitations are being issued, but all Antarctic Travellers and others who would like to be present, or who are interested, are asked to communicate with Mr. J. M. Wordie, St. John's College, Cambridge, as early as possible.

## CORRESPONDENCE

### Mr. W. B. Cabot's Book on Labrador.

IN reviewing Mr. William Cabot's latest book on Labrador for the *Journal* last summer (June number, p. 468), I commented on an apparent discrepancy between the publisher's statement on the wrapper, as to the extent of the author's experience of the region in question, and the information given in the book itself. Mr. Cabot has, however, written most courteously to explain that the mention of expeditions in the book is not exhaustive, and that his experience of Labrador in fact goes back to a date and covers an extent of territory corresponding to the publisher's statement. As I have always had a very great respect for Mr. Cabot's performances as a traveller, I much regret that I should have been misled into doing either him or his publisher any injustice, and I shall be glad if you will allow it to be known, through this letter, that Mr. Cabot's experience of Labrador is far more considerable than can be gathered from reading his book.

G. M. GATHORNE-HARDY.

5, Sumner Terrace, S.W., 10 January 1923.

## MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1922–1923

**Fourth Evening Meeting, 15 January 1923.**—The President in the Chair.

ELECTIONS.—Henry Alldis; Douglas Coningsby Algar-Bailey; Harry Bardsley Chaplin Baldwin, M.A., F.C.A.; Mrs. Paulin Pickard-Cambridge; Lieut.-Colonel James Henry Gordon Casserley; P. L. Collignon; The Earl Cawdor; Squadron Leader Hugh Vivian Champion de Crespigny; The Rev. Canon John Carlyon Vavasor Durell, B.D., C.B.E.; A. E. Fearnley; Walter Leonard Flinn; Warren Dunham Foster; Frederic de Garis; Albert Downing C. Hooper; Capt. Rustam Merwam Kharegat, I.M.S.; Capt. Ernest William Luttman, I.A.; Miss A. D. Muncaster; Major-General Sir Frederick Spencer Robb, K.C.B., K.C.M.G., K.C.V.O.; Cyril Rayner-Smith; Richard Henry Stevens; Capt. Michael Sweeny; The Rev. Canon Samuel Augustus Swaby, B.D.; James Frederick Gordon Thomson; Miss Hilda Annie Wilcox.

Paper: The Yugo-Slavia—Hungarian Boundary. Lieut.-Colonel D. Cree.